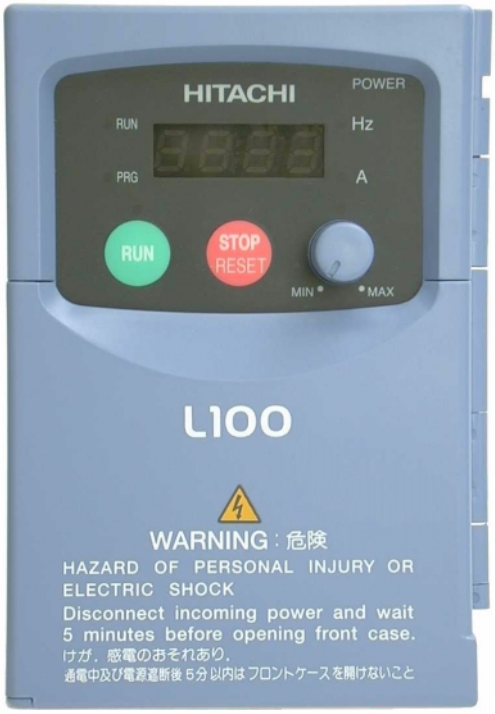
HITACHI

L100 Series Inverter Instruction Manual

- Single-phase Input 200V Class
- Three-phase Input 200V Class
- Three-phase Input 400V Class



Manual Number: NB576XA

After reading this manual, keep it handy for future reference.

Hitachi, Ltd.
Tokyo Japan

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Safety Messages

For the best results with the L100 Series inverter, carefully read this manual and all of the warning labels attached to the inverter before installing and operating it, and follow the instructions exactly. Keep this manual handy for quick reference.

Definitions and Symbols

A safety instruction (message) includes a hazard alert symbol and a signal word, WARNING or CAUTION. Each signal word has the following meaning:

HIGH VOLTAGE: This symbol indicates high voltage. It calls your attention to items or operations that could be dangerous to you and other persons operation this equipment. Read the message and follow the instructions carefully.

This symbol is the “Safety Alert Symbol.” It occurs with either of two signal words: CAUTION or WARNING, as described below.

WARNING: Indicates a potentially hazardous situation which, if not avoided, can result in serious injury or death.

CAUTION: Indicates a potentially hazardous situation which, if not avoided, can result in minor to moderate injury, or serious damage to the product. The situation described in the **CAUTION** may, if not avoided, lead to serious results. Important safety measures are described in CAUTION (as well as WARNING), so be sure to observe them.

Step 1: Indicates a step in a series of action steps to accomplish a goal.

NOTE: Notes indicate an area or subject of special merit, emphasizing either the product’s capabilities or common errors in operation or maintenance.

TIP: Tips give a special instruction that can save time or provide other benefits while installing or using the product. The tip calls attention to an idea that may not be obvious to first-time users of the product.

Hazardous High Voltage

HIGH VOLTAGE: Motor control equipment and electronic controllers are connected to hazardous line voltages. When servicing drives and electronic controllers, there may be exposed components with housings or protrusions at or above line potential. Extreme care should be taken to protect against shock.

Stand on an insulating pad and make it a habit to use only one hand when checking components. Always work with another person in case an emergency occurs. Disconnect power before checking controllers or performing maintenance. Be sure equipment is properly grounded. Wear safety glasses whenever working on electronic controllers or rotating machinery.

General Precautions - Read These First!

WARNING: This equipment should be installed, adjusted, and serviced by qualified electrical maintenance personnel familiar with the construction and operation of the equipment and the hazards involved. Failure to observe this precaution could result in bodily injury.

WARNING: The user is responsible for ensuring that all driven machinery, drive train mechanism not supplied by Hitachi, Ltd., and process line material are capable of safe operation at an applied frequency of 150% of the maximum selected frequency range to the AC motor. Failure to do so can result in destruction of equipment and injury to personnel should a single-point failure occur.

WARNING: For equipment protection, install a ground leakage type breaker with a fast response circuit capable of handling large currents. The ground fault protection circuit is not designed to protect against personal injury.

HIGH VOLTAGE: HAZARD OF ELECTRICAL SHOCK. DISCONNECT INCOMING POWER BEFORE WORKING ON THIS CONTROL.

WARNING: Wait at least five (5) minutes after turning off the input power supply before performing maintenance or an inspection. Otherwise, there is the danger of electric shock.

CAUTION: These instructions should be read and clearly understood before working on L100 series equipment.

CAUTION: Proper grounds, disconnecting devices and other safety devices and their location are the responsibility of the user and are not provided by Hitachi, Ltd.

CAUTION: Be sure to connect a motor thermal cutoff switch or overload device to the L100 series controller to assure that the inverter will shut down in the event of an overload or an overheated motor.

HIGH VOLTAGE: Dangerous voltage exists until power light is off. Wait at least 5 minutes after input power is disconnected before performing maintenance.

WARNING: This equipment has high leakage current and must be permanently(fixed) hard-wired to earth via two independent cables.

WARNING: Rotating shafts and above-ground electrical potentials can be hazardous. Therefore, it is strongly recommended that all electrical work conform to the National Electrical Codes and local regulations. Installation, alignment and maintenance should

be performed only by qualified personnel.
Factory-recommended test procedures included in the instruction manual should be followed. Always disconnect electrical power before working on the unit.

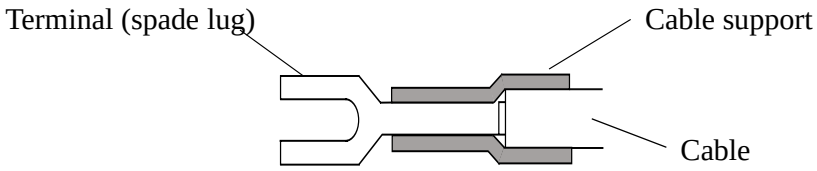
CAUTION:
a) Class I motor must be connected to protective earth via low resistive path (< 0.1ohm)
b) Any motor used must be of a suitable rating.
c) Motors may have hazardous moving parts. In this event suitable protection must be provided.

CAUTION: Alarm connection may contain hazardous live voltage even when inverter is disconnected. When removing the front cover for maintenance or inspection, confirm that incoming power for alarm connection is completely disconnected.

CAUTION: Hazardous (main) terminals for any interconnection (motor, contact breaker, filter, etc.) must be inaccessible in the final installation.

CAUTION: This equipment should be installed in IP54 or equivalent (see EN60529) enclosure. The end application must be in accordance with BS EN60204-1. Refer to the section on inverter mounting, starting on page 2–6. The diagram dimensions are to be suitably amended for your application.

CAUTION: Connection to field wiring terminals must be reliably fixed having two independent means of mechanical support. Using a termination with cable support (figure below), or strain relief, cable clamp, etc.



CAUTION: A double-pole disconnection device must be fitted to the incoming mains supply close to the inverter. Additionally, a protection device meeting IEC947-1/ IEC947-3 must be fitted at this point (protection device data shown in page 2–13).

NOTE: The above instructions, together with any other requirements are highlighted in this manual, and must be followed for continued LVD (European Low Voltage Directive) compliance.

Precautions for EMC (Electromagnetic Compatibility)

You are required to satisfy the EMC directive (89/336/EEC) when using an L100 inverter in a European country. To satisfy the EMC directive and to comply with standard, follow the checklist below.

WARNING: This equipment should be installed, adjusted, and serviced by qualified personal familiar with construction and operation of the equipment and the hazards involved. Failure to observe this precaution could result in bodily injury.

1. The power supply to L100 inverter must meet these specifications:

- **a.** Voltage fluctuation+/- 10% or less
- **b.** Voltage imbalance +/- 3% or less
- **c.** Frequency variation +/- 4% or less
- **d.** Voltage distortion THD = 10% or less

2. Installation measure:

- **a.** Use a filter designed for L100 inverter

3. Wiring:

- **a.** Shielded wire (screened cable) is required for motor wiring, and the length must be less than 50 meters.
- **b.** The carrier frequency setting must be less than 5 kHz to satisfy EMC requirements.
- **c.** Separate the main circuit from the signal/process circuit wiring.

4. Environmental conditions - when using a filter, follow these guidelines:

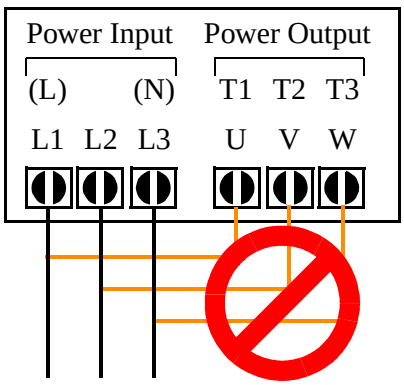
- **a.** Ambient temperature: -10 to 40 °C
- **b.** Humidity: 20 to 90% RH (non-condensing)
- **c.** Vibration: 5.9 m/sec^2 (0.6 G) 10 ~ 55Hz
- **d.** Location: 1000 meters or less altitude, indoors (no corrosive gas or dust)

Index to Warnings and Cautions in This Manual

Installation - Cautions for Mounting Procedures

Wiring - Warnings for Electrical Practices and Wire Specifications

Wiring - Cautions for Electrical Practices



NOTE:
L, N: Single-phase 200 to 240V 50/60 Hz
L1, L2, L3: Three-phase 200 to 240V 50/60 Hz
Three-phase 380 to 460V 50/60 Hz

Powerup Test Caution Messages

Warnings for Operations and Monitoring

Cautions for Operations and Monitoring

Warnings and Cautions for Troubleshooting and Maintenance

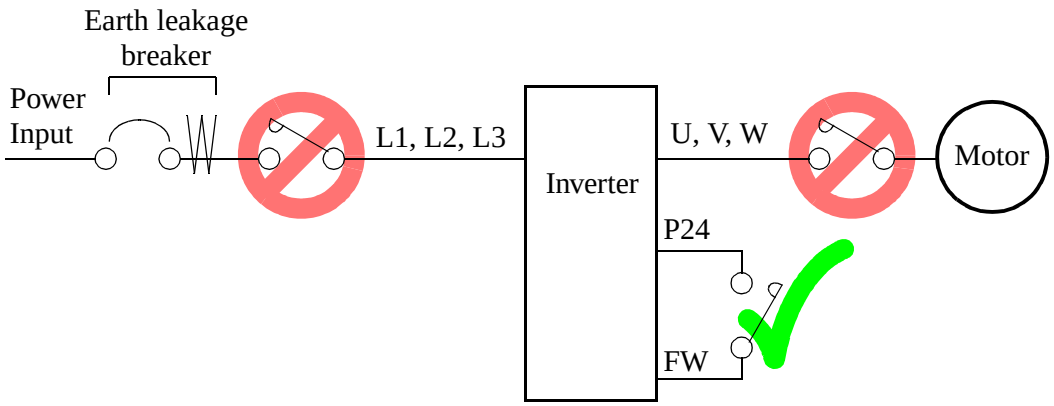
General Warnings and Cautions

WARNING: Never modify the unit. Otherwise, there is a danger of electric shock and/or injury.

CAUTION: Withstand voltage tests and insulation resistance tests (HIPOT) are executed before the units are shipped, so there is no need to conduct these tests before operation.

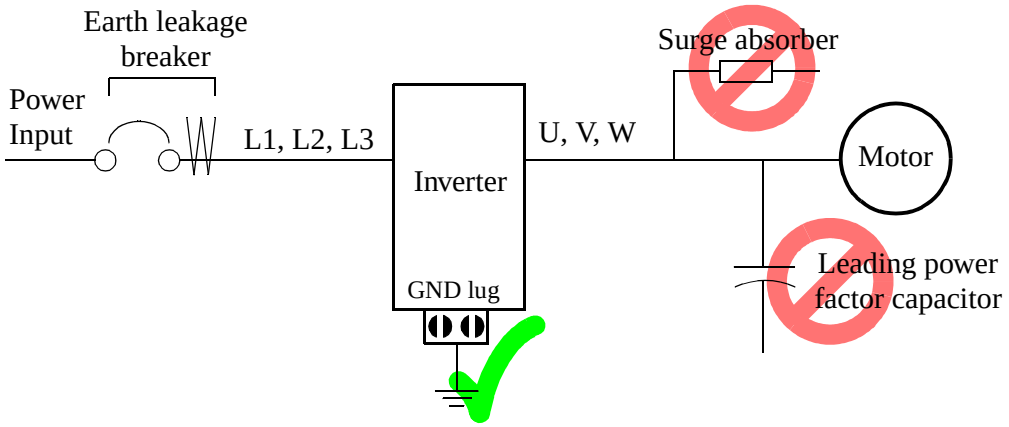
CAUTION: Do not attach or remove wiring or connectors when power is applied. Also, do not check signals during operation.

CAUTION: Do not stop operation by switching off electromagnetic contactors on the primary or secondary sides of the inverter.



When there has been a sudden power failure while an operation instruction is active, then the unit may restart operation automatically after the power failure has ended. If there is a possibility that such an occurrence may harm humans, then install an electromagnetic contactor (Mgo) on the power supply side, so that the circuit does not allow automatic restarting after the power supply recovers. If the optional remote operator is used and the retry function has been selected, this will also cause automatic restarting when an operation instruction is active. So, please be careful.

CAUTION: Do not insert leading power factor capacitors or surge absorbers between the output terminals of the inverter and motor.



CAUTION: Be sure to connect the grounding terminal to earth ground.

CAUTION: When inspecting the unit, be sure to wait five minutes after tuning off the power supply before opening the cover.

CAUTION: MOTOR TERMINAL SURGE VOLTAGE SUPPRESSION FILTER (For the 400 V CLASS)

In a system using an inverter with the voltage control PWM system, a voltage surge caused by the cable constants such as the cable length (especially when the distance between the motor and inverter is 10 m or more) and cabling method may occur at the motor terminals. A dedicated filter of the 400 V class for suppressing this voltage surge is available. Be sure to install a filter in this situation.

CAUTION: SUPPRESSION FOR NOISE INTERFERENCE FROM INVERTER

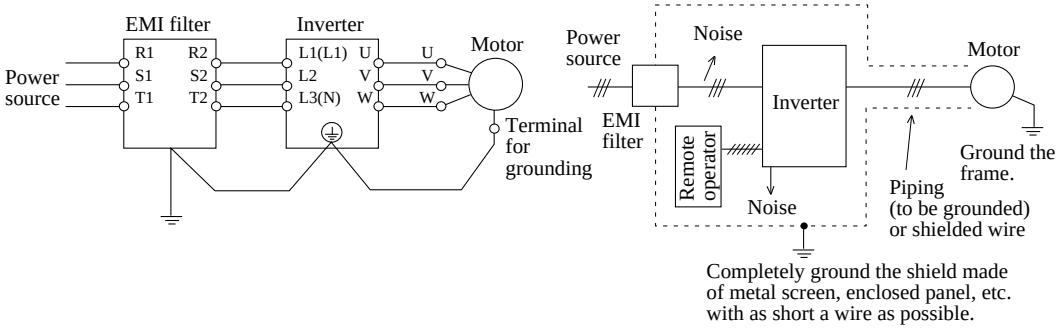
The inverter uses many semiconductor switching elements such as transistors and IGBTs. Thus, a radio receiver or measuring instrument located near the inverter is susceptible to noise interference.

To protect the instruments from erroneous operation due to noise interference, they should be used well away from the inverter. It is also effective to shield the whole inverter structure.

The addition of an EMI filter on the input side of the inverter also reduces the effect of noise from the commercial power line on external devices.

Note that the external dispersion of noise from the power line can be minimized by connecting an EMI filter on the primary side of inverter.

CAUTION: EFFECTS OF DISTRIBUTOR LINES ON INVERTERS



In the cases below involving a general-purpose inverter, a large peak current flows on the power supply side, sometimes destroying the converter module. Where such situations are foreseen, or the paired equipment must be highly reliable, install an AC reactor between the power supply and the inverter.

1. The unbalance factor of the power supply is 3% or higher.
2. The power supply capacity is at least 10 times greater than the inverter capacity (and the power supply capacity, 500 kVA or more).
3. Abrupt power supply changes are expected.
   Some examples include:
   a.Several inverters are interconnected with a short bus.
   b.A thyristor converter and an inverter are interconnected with a short bus.
   c:An installed phase advance capacitor opens and closes.

In cases (1), (2), and (3) we recommend installing an AC reactor of 3% (at a voltage drop at rated current) with respect to the supply voltage on the power supply side.

CAUTION: When the EEPROM error E8 occurs, be sure to confirm the setting value again.

CAUTION: When setting b contact to the forward or reverse command [FW], [RV] terminal, the inverter starts automatically. Do not set to b contact without a purpose.

General Caution

CAUTION: In all the illustrations in this manual, covers and safety devices are occasionally removed to describe the details. While operating the product, make sure that the covers and safety devices are placed as they were specified originally and operate it according to the instruction manual.

Revisions

Revision History Table

No.	Revision Comments	Date of Issue	Operation Manual No.
	Initial Release of Manual NB576X	May 1999	NB576X
1	Revision A Pages 1-4 – Specs tables: added row for input curent, changed rated input voltage tolerance, corrected dynamic braking %torque, corrected product weight (lbs) Page 2-8 – Corrected H dimension for -002 models	August 1999	NB576XA

Getting Started

1

In This Chapter.... page

Introduction

Main Features

Congratulations on your purchase of an L100 Series Hitachi inverter! This inverter drive features state-of-the-art circuitry and components to provide high performance. The housing footprint is exceptionally small, given the size of the corresponding motor. The Hitachi L100 product line includes more than a dozen inverter models to cover motor sizes from 1/4 horsepower to 10 horsepower, in either 230 VAC or 460 VAC power input versions. The main features are:

Model L100-002NFU

- Convenient keypad for parameter settings
- Built-in RS-422 communications interface to allow configuration from a PC and for field bus external modules.
- Sixteen programmable speed levels
- Two-step acceleration and deceleration curves
- PID control adjusts motor speed automatically to maintain a process variable value

The design in Hitachi inverters overcomes many of the traditional trade-offs between speed, torque and efficiency. The performance characteristics are:

- V/F (volts-per-hertz) control algorithm, selectable for either constant or reduced torque loads
- Output frequency range from 0.5 to 360 Hz
- Continuous torque operation at 100% within a 1:10 speed range (6/60 Hz / 5/50 Hz) without motor derating

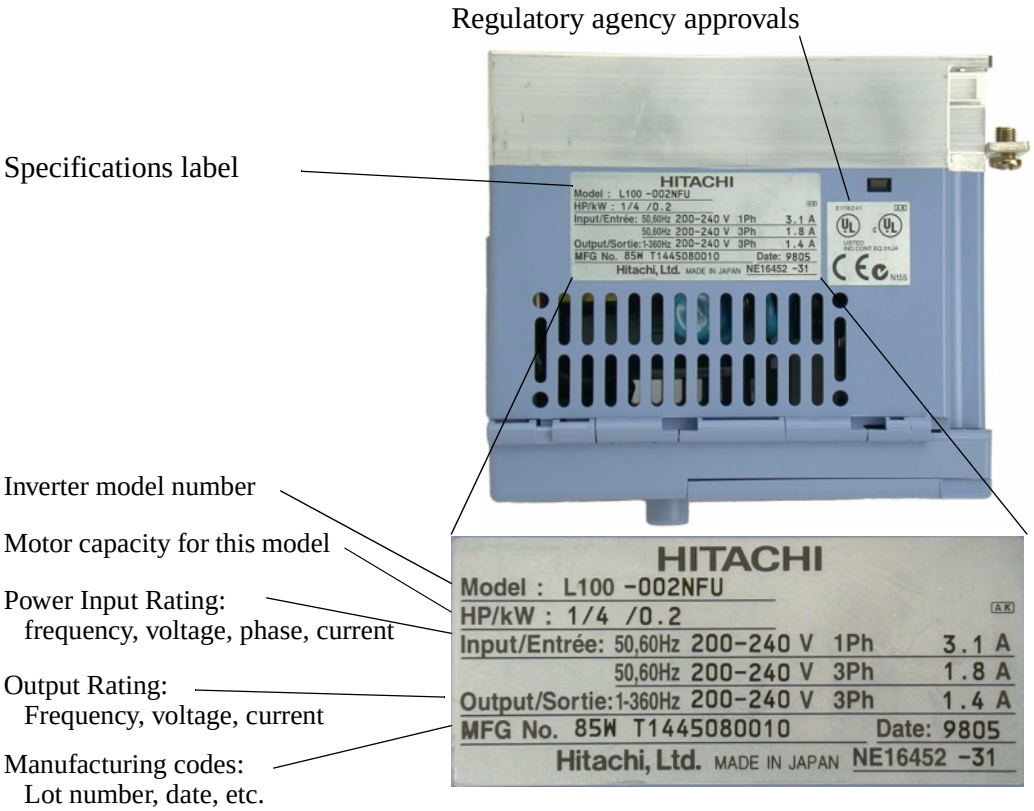
A full line of accessories from Hitachi is available to complete your application:

- Digital remote operator keypad
- Dynamic braking unit
- Radio noise filters and EMI filters (shown below)
- CE compliance filters
- DIN rail mounting adapter (35mm rail size)

EMI Filter

Inverter Specifications Label

The Hitachi L100 inverters have product labels located on the right side of the housing, as pictured below. Be sure to verify that the specifications on the labels match your power source, motor, and application safety requirements.



Model Number Convention

The model number for a specific inverter contains useful information about its operating characteristics. Refer to the model number legend below:

L100 — 004 H F U 5

Series name

Version number (_, 1, 2, ...)

Restricted distribution:
E=Europe, U=USA

Configuration type
F = with digital operator (keypad)

Input voltage:
N = single or three-phase 200V class
H = three-phase 400V class
L = three phase only, 200V class

Applicable motor capacity in kW

001 = 0.1 kW	022 = 2.2 kW
002 = 0.2 kW	030 = 3.0 kW
004 = 0.4 kW	037 = 3.7 kW
005 = 0.55 kW	040 = 4.0 kW
007 = 0.75 kW	055 = 5.5 kW
011 = 1.1 kW	075 = 7.5 kW
015 = 1.5 kW	

L100 Inverter Specifications

Model-specific tables for 200V and 400V class inverters

The following three tables are specific to L100 inverters for the 200V and 400V class model groups. The table on page 1–6 gives the general specifications that apply to both voltage class groups. Footnotes for all specifications tables are on the next page.

Item			200V Class Specifications				
L100 inverters, 200V models			002NFE 002NFU	004NFE 004NFU	005NFE —	007NFE 007NFU	011NFE —
Applicable motor size *2		kW	0.2	0.4	0.55	0.75	1.1
		HP	1/4	1/2	3/4	1	1 1/2
Rated capacity (240V) kVA *10			0.5	1.0	1.2	1.6	2.0
Rated input voltage			1-phase: 200 to 240V +5%/-10%, 3-phase: 200 to 230V ±10%, 50/60 Hz ±5% (037LFU, 055LFU & 075LFU 3-phase only)				
Rated input current (A), (1-ph / 3-ph)			3.1 / 1.8	5.8 / 3.4	6.7 / 3.9	9.0 / 5.2	11.2 / 6.5
Rated output voltage *3			3-phase 200 to 240V (corresponding to input voltage)				
Rated output current (A)			1.4	2.6	3.0	4.0	5.0
Braking	Dynamic braking, approx. % torque, (short time, stopping from 50 / 60 Hz) *5		100%: ≤ 50Hz, 50%: ≤ 60 Hz				
			Capacitive feedback type, dynamic braking unit and braking resistor optional, individually installed				
	DC braking		Variable operating frequency, time, and braking force				
Weight	kg / lb		0.8 / 1.9	0.8 / 1.9	1.3 / 2.9	1.3 / 2.9	2.2 / 4.8

Item			200V Class Specifications, continued				
L100 inverters, 200V models			015NFE 015NFU	022NFE 022NFU	— 037LFU	— 055LFU	— 075LFU
Applicable motor size *2		kW	1.5	2.2	3.7	5.5	7.5
		HP	2	3	5	7.5	10
Rated capacity (240V) kVA *10			2.9	4.1	6.3	9.6	12.7
Rated input voltage			1-phase: 200 to 240V ±10%, 3-phase: 200 to 230V ±10%, 50/60 Hz ±5% (037LFU, 055LFU & 075LFU 3-phase only)				
Rated input current (A), (1-ph / 3-ph)			16.0 / 9.3	22.5 / 13.0	– / 20.0	– / 30.0	– / 40.0
Rated output voltage *3			3-phase 200 to 240V (corresponding to input voltage)				
Rated output current (A)			7.1	10.0	15.9	24	32
Braking	Dynamic braking, approx. % torque, (short time, stopping from 50 / 60 Hz) *5		100%: ≤ 50Hz 50%: ≤ 60Hz	40%: ≤ 50Hz 20%: ≤ 60Hz		20%: ≤ 50Hz 20%: ≤ 60Hz	
			Capacitive feedback type, dynamic braking unit and braking resistor optional, individually installed				
	DC braking		Variable operating frequency, time, and braking force				
Weight	kg / lb		2.2 / 4.8	2.8 / 6.2	2.8 / 6.2	5.5 / 12.1	5.7 / 12.6

Item		400V Class Specifications							
L100 inverters, 400V models		004HFE 004HFU	007HFE 007HFU	015HFE 015HFU	022HFE 022HFU	030HFE —	040HFE 040HFU	055HFE 055HFU	075HFE 075HFU
Applicable motor size *2	kW	0.4	0.75	1.5	2.2	3.0	4.0	5.5	7.5
	HP	1/2	1	2	3	4	5	7.5	10
Rated capacity (460V) kVA *10		1.1	1.9	3.0	4.3	6.2	6.8	10.4	12.7
Rated input voltage		3-phase: 380 to 460V ±10%, 50/60 Hz ±5%							
Rated input current (A)		2.0	3.3	5.0	7.0	10.0	11.0	16.5	20.0
Rated output voltage *3		3-phase: 380 to 460V (corresponding to input voltage)							
Rated output current (A)		1.5	2.5	3.8	5.5	7.8	8.6	13	16
Braking	Dynamic braking, approx. % torque, (short time, stopping from 50 / 60 Hz) *5	100%: ≤ 50Hz 50%: ≤ 60Hz			40%: ≤ 50Hz, 20%: ≤ 60Hz			20%: ≤ 50Hz 20%: ≤ 60Hz	
		Capacitive feedback type, dynamic braking unit and braking resistor optional, individually installed							
	DC braking	Variable operating frequency, time, and braking force							
Weight	kg / lb	1.3/2.9	1.7/3.7	1.7/3.7	2.8/6.2	2.8/6.2	2.8/6.2	5.5/12.1	5.7/12.5

Footnotes for the preceding tables and the table on the following page:

*1: The protection method conforms to JEM 1030.

*2: The applicable motor refers to Hitachi standard 3-phase motor (4-pole). To use other motors, care must be taken to prevent the rated motor current (50/60 Hz) from exceeding the rated output current of the inverter.

*3: The output voltage decreases as the main supply voltage decreases (except for use of the AVR function). In any case, the output voltage cannot exceed the input power supply voltage.

*4: To operate the motor beyond 50/60 Hz, consult the motor manufacturer about the maximum allowable rotation speed.

*5: The braking torque via capacitive feedback is the average deceleration torque at the shortest deceleration (stopping from 50/60 Hz as indicated). It is not continuous regenerative braking torque. And, the average deceleration torque varies with motor loss. This value decreases when operating beyond 50 Hz. Note that a braking unit is not included in the inverter. If a large regenerative torque is required, the optional regenerative braking unit should be used.

*6: The frequency command is the maximum frequency at 9.8V for input voltage 0 to 10 VDC, or at 19.6 mA for input current 4 to 20 mA. If this characteristic is not convenient for your application, contact your Hitachi sales representative.

*7: If operating the inverter in an ambient temperature of 40–50° C, reduce the carrier frequency to 2.1 kHz, derate the output current by 80%, and remove the top housing cover. Note that removing the top cover will nullify the NEMA rating for the inverter housing.

*8: The storage temperature refers to the short-term temperature during transport.

*9: Conforms to the test method specified in JIS C0911 (1984). For the model types excluded in the standard specifications, contact your Hitachi sales representative.

*10: The input voltage of xxLFU is 230V.

General Specifications

The following table applies to all L100 inverters.

Item			General Specifications
Protective housing *1			IP20
Control method			Sine wave pulse-width modulation (PWM) control
Output frequency range *4			0.5 to 360 Hz
Frequency accuracy			Digital command: 0.01% of the maximum frequency Analog command: ±0.2% of the maximum frequency (25°C ± 10°C)
Frequency setting resolution			Digital: 0.1 Hz; Analog: max. frequency/1000
Volt./Freq. characteristic			V/F optionally variable, V/F control (constant torque, reduced torque)
Overload current rating			150%, 60 seconds
Acceleration/deceleration time			0.1 to 3000 sec., (linear accel/decel), second accel/decel setting available
Input signal	Freq. setting	Operator panel	Up and Down keys / Value settings
		Potentiometer	Analog setting
		External signal *6	0 to 10 VDC (input impedance 10k Ohms), 4 to 20 mA (input impedance 250 Ohms), Potentiometer (1k to 2k Ohms, 2W)
	FWD/ REV Run	Operator panel	Run/Stop (Forward/Reverse run change by command)
		External signal	Forward run/stop, Reverse run/stop
	Intelligent input terminal		FW (forward run command), RV (reverse run command), CF1~CF4 (multi-stage speed setting), JG (jog command), 2CH (2-stage accel./decel. command), FRS (free run stop command), EXT (external trip), USP (startup function), SFT (soft lock), AT (analog current input select signal), RS (reset), PTC (thermal protection)
Output signal	Intelligent output terminal		RUN (run status signal), FA1,2 (frequency arrival signal), OL (overload advance notice signal), OD (PID error deviation signal), AL (alarm signal)
	Frequency monitor		PWM output; Select analog output frequency monitor, analog output current monitor or digital output frequency monitor
Alarm output contact			ON for inverter alarm (1C contacts, both normally open or closed avail.)
Other functions			AVR function, curved accel/decel profile, upper and lower limiters, 16-stage speed profile, fine adjustment of start frequency, carrier frequency change (0.5 to 16 kHz) frequency jump, gain and bias setting, process jogging, electronic thermal level adjustment, retry function, trip history monitor
Protective function			Over-current, over-voltage, under-voltage, overload, extreme high/low temperature, CPU error, memory error, ground fault detection at startup, internal communication error, electronic thermal
Operating Environment	Ambient storage humidity		-10 to 50°C (*7) / -25 to 70°C (*8) / 20 to 90% humidity (non-condensing)
	Vibration *9		5.9 m/s^2 (0.6G), 10 to 55 Hz
	Location		Altitude 1,000 m or less, indoors (no corrosive gasses or dust)
Coating color			Light purple, cooling fins in base color of aluminum
Options			Remote operator unit, copy unit, cables for the units, dynamic braking unit, braking resistor, AC reactor, DC reactor, noise filter, DIN rail mounting

Introduction to Variable-Frequency Drives

The Purpose of Motor Speed Control for Industry

Hitachi inverters provide speed control for 3-phase AC induction motors. You connect AC power to the inverter, and connect the inverter to the motor. You're probably familiar with the way a light dimmer works to vary the power sent to a light bulb, and thus the light intensity. At a basic level, the modern inverter serves the same role for a motor.

Many industrial applications use AC motors of all sizes to do many different things. In some cases, the motor connects directly to an AC power source — running at full speed whenever it is on. However, many applications benefit from a motor with variable speed, in several ways:

- Energy savings - HVAC
- Need to coordinate speed with an adjacent process - textiles and printing presses
- Sensitive loads - elevators, food processing, pharmaceuticals

Over the years, industry has found many ways to achieve variable speed when it benefited the process. Solutions varied from mechanical (belts and gears), hydraulic (pumps and motors), and electrical (two-speed motor windings, etc.) While these solutions provided some control over speed, there were unwanted side effects as well:

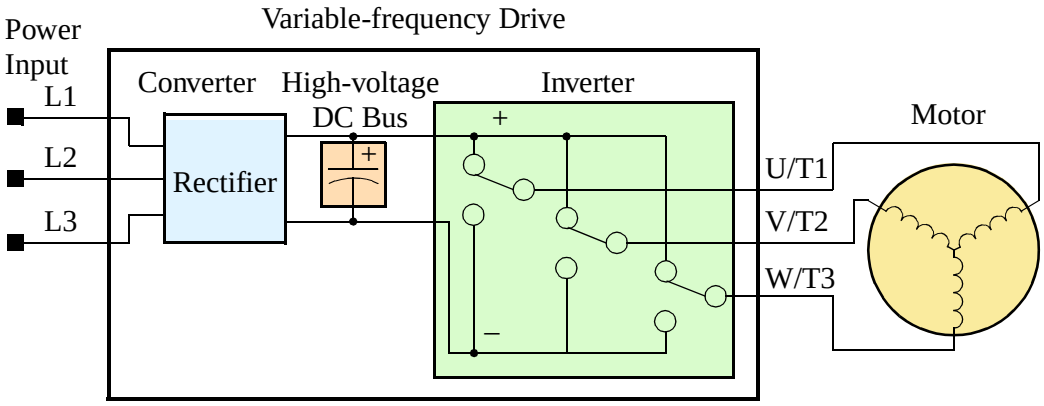
- Wasted energy from losses in speed-adjusting mechanisms (gearboxes, etc.)
- Wasted energy from on/off control trying to approximate an average
- Noise from belts and gears or start/stop operations
- Messy machinery with fluid leaks
- High maintenance and/or unreliable components
- Could set the speed, but acceleration and deceleration was still uncontrollable
- Not enough speed levels
- Poor torque performance at low speeds

Most of the unwanted side effects came from mechanical or hydraulic machinery, and could be solved with a purely electronic solution. But early electronic components had reliability shortcomings due to the large currents and high voltages imposed on the devices. However, the modern power components in use today have changed all that. The state-of-the-art components in Hitachi drives provide all the benefits of speed control, while overcoming the classical problems listed above.

What is an Inverter?

The term *inverter* and *variable-frequency drive* are related and somewhat interchangeable. An electronic motor drive for an AC motor can control the motor's speed by *varying the frequency* of the power sent to the motor. For example, a particular motor may be designed for 60 Hz operation. We say it is a *synchronous* motor if its speed of revolution is directly related to its power input frequency. When the motor design is synchronous, a variable frequency drive is able to control the speed by controlling the frequency.

An inverter, in general, is a device that converts DC power to AC power. The popular consumer power inverter is designed for powering an AC appliance from a car battery; put 12VDC in, and get 115VAC 50/60 Hz out, for example. The figure below shows how the variable-frequency drive employes an internal inverter. The drive first converts incoming AC power to DC through a rectifier circuit, creating a high-voltage internal DC bus. Then the inverter circuit inverts the DC back to AC again to power the motor. However, this special inverter varies its output frequency and voltage according to the desired motor speed.

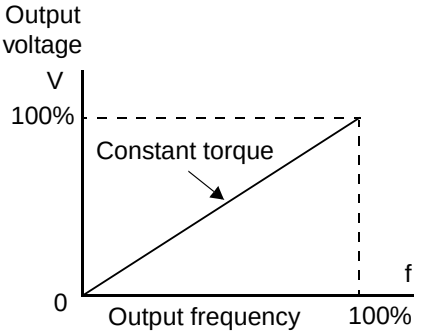


The simplified drawing of the inverter shows three double-throw switches. Usually implemented with six power transistors, outputs U/T1, V/T2, and W/T3 may switch positively or negatively. Using a commutation algorithm, the microprocessor in the drive switches the power transistors on and off at a very high speed to create the desired output waveforms. The reactance of the motor windings helps smooth out the pulses.

Torque and Constant Volts/Hertz Operation

In working with industrial motors we often discuss the motor *torque*. That is simply the rotational force the motor exerts at any given time. The goal of the inverter is to control motor speed, but the L100 inverter only has direct control over the output frequency and voltage. The no-load speed will be equal to the inverter output frequency minus a small amount of slip in the motor (slip is the difference between theoretical motor speed and actual speed). As the load increases, the slip and the delivered torque also increase . If the inverter can create strong motor torque over most or all of the speed range, then it is relatively easy for the system to achieve any desired speed. *Speed regulation* is a measure of the accuracy speed control, given as a percent difference from a fixed value. The L100 delivers speed regulation (no load to full load) within 3% of the (full scale) motor nameplate speed value.

When varying the output frequency, the inverter drive also must vary the output voltage in proportion to the frequency. It does so because of the motor's characteristic inductive reactance. If the drive maintains a constant volts-per-hertz ratio, the motor will have constant torque characteristics. Constant torque is desirable for most applications, because it transfers power to the load consistently across the entire speed range.



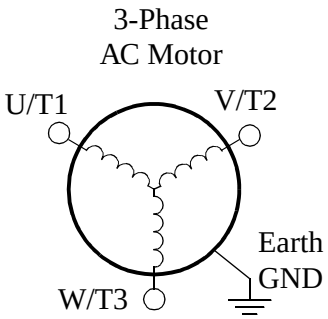
Inverter Input and Three-Phase Power

Heavy industrial machinery often needs the additional power available from higher voltage/current sources, and from three-phase power. The Hitachi L100 Series of inverters includes two sub-groups: the 200V class and the 400V class inverters. The drives described in this manual may be used in either the United States or Europe, although the exact voltage level for commercial power may be slightly different from country to country. Accordingly, a 200V class inverter requires (nominal) 200 to 240VAC, and a 400V class inverter requires from 380 to 460VAC. Some 200V class inverters will accept single-phase or three-phase power, but all 400V class inverters require a three-phase power supply.

The common terminology for single phase power is Line (L) and Neutral (N). Three-phase power connections are usually labeled Line 1 (L1), Line 2 (L2) and Line 2 (L3). In any case, the power source should include an earth ground connection. That ground connection will need to connect to the inverter chassis and to the motor frame (description given on page 2–16).

Inverter Output to the Motor

The AC motors also use three-phase power, but they must connect only to the inverter's output terminals. The output terminals are uniquely labeled (to differentiate them from the input terminals) with the designations U/T1, V/T2, and W/T3. This corresponds to typical motor lead connection designations T1, T2, and T3. It is generally not critical to connect a particular inverter output to a particular motor lead for a new application. The consequence of swapping any two of the three connections is the reversal of the motor direction. For safety reasons, you must connect the motor chassis ground to the ground connection at the bottom of the inverter housing.

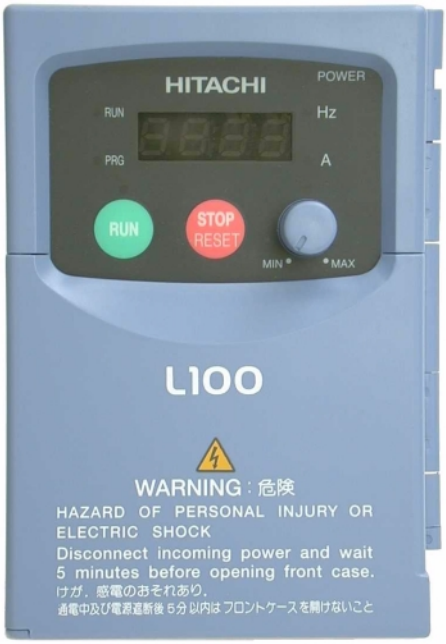


Notice the three connections to the motor do not include one marked "Neutral" or "Return." The motor represents a balanced "Y" impedance to the inverter, so there is no need for a separate return. In other words, each of the three "Hot" connections serves also as a return for the other connections, because of their phase relationship.

The Hitachi inverter is a rugged and reliable device. The intention is for the inverter to assume the role of switching power to the motor during all normal operations. Therefore, this manual instructs you not to switch off power to the inverter *while the motor is running* (unless it is an emergency stop). Also, do not install or use cut-off switches in the wiring from the inverter to the motor (except thermal cut-off). Of course, safety-related devices such as fuses must be in the design to break power during a malfunction.

Intelligent Functions and Parameters

Much of this manual is devoted to describing how to use inverter functions and how to configure inverter parameters. The inverter is microprocessor-controlled, and has many independent functions. The microprocessor has an on-board EEPROM for parameter storage. The inverter's front panel keypad provides access to all functions and parameters, which you can access through other devices as well. The general name for all these devices is the *digital operator*, or *digital operator panel*. Chapter 2 will show you how to get a motor running, using a minimal set of function commands or configuring parameters.



The optional read/write programmer will let you read and write inverter EEPROM contents from the programmer. This feature is particularly useful for OEMs who need to duplicate a particular inverter's settings in many other inverters in assembly-line fashion.

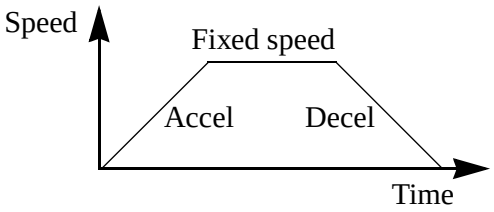
Braking

In general, braking is a force that attempts to slow or stop motor rotation. So it is associated with motor deceleration, but may also occur even when the load attempts to drive the motor faster than the desired speed. If you need the motor and load to decelerate quicker than their natural deceleration during coasting, we recommend installing an optional dynamic braking unit. See pages 5–2 and 5–5 for more information on the BRD–E2 and BRD–EZ2 braking units. The L100 inverter sends excess motor energy into the resistor in the dynamic braking unit to slow the motor and load. If you have a load that tries to drive the motor continuously for some period of time, that will require a different type of inverter with continuous regenerative capability. As an example, elevator control usually requires fast acceleration and deceleration profiles, so you may need to add a dynamic braking unit. However, an application such as running an HVAC fan may just coast to a stop in most cases.

The inverter parameters include acceleration and deceleration, which you can program to match the needs of the application. For a particular inverter, motor, and load, there will be a range of practically achievable accelerations and decelerations.

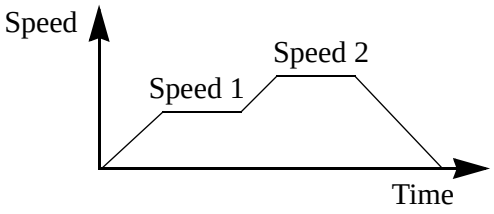
Velocity Profiles

The L100 inverter is capable of sophisticated speed control. A graphical representation of that capability will help you understand and program the associated parameters. This manual makes use of the velocity profile graph used in industry (shown at right). In the example, the acceleration is a ramp to a set speed, and the deceleration is a decline to a stop.



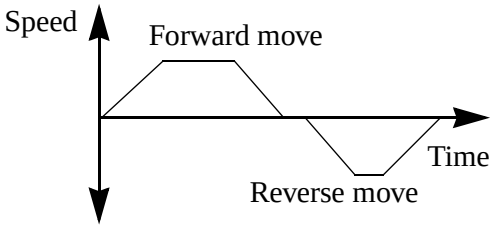
Velocity Profile

The L100 inverter can store up to 16 preset speeds. And, it can apply separate acceleration and deceleration transitions from any preset to any other preset speed. For example, a motor with a small load could use high accel/decel values, but a heavy load will generally use slower speed changes. A multi-speed profile (shown at right) uses two or more preset speeds in one motion of the load. There is no limit to the number of speed changes for one motion; that is up to the control input to the inverter. Also note that speed can be infinitely variable across the speed range. You can use the potentiometer control on the keypad for manual control. The drive also accepts analog 0-10V signals and 4-20 mA control signals as well.



Multi-speed Profile

The inverter can drive the motor in either direction. Separate FWD and REV commands select the direction of rotation. The motion profile example shows a forward motion followed by a reverse motion of shorter duration. The speed presets and analog signals control the magnitude of the speed, while the FWD and REV commands determine the direction before the motion starts.



Bi-directional Profile

NOTE: The L100 can move loads in both directions. However, it is not designed for use in servo-type applications that use a bipolar velocity signal which determines direction.

Frequently Asked Questions

Q. What is the main advantage in using an inverter to drive a motor, compared to alternative solutions?

A. An inverter can vary the motor speed with very little loss of efficiency, unlike mechanical or hydraulic speed control solutions. The resulting energy savings usually pays for the inverter in a relatively short time.

Q. The term “inverter” is a little confusing, since we also use “drive” and “amplifier” to describe the electronic unit that controls a motor. What does “inverter” mean?

A. The terms *inverter*, *drive*, and *amplifier* are used somewhat interchangeably in industry. But there are subtle differences. A *drive* can refer to the motor, the control electronics, or both. This term is used particularly when the motor and electronics are integrated in the same housing. The term *variable speed drive* can include many types of devices – anything that has a variable speed output, which includes the Hitachi inverter. *Amplifier* more commonly refers to a linear amplifier for servo motor control, or a stepper motor driver IC. Finally, we use *inverter* to describe the Hitachi motor controller because of the way the switching electronics alternately *inverts* or *directly* couples its internal DC voltage bus to generate a variable AC output.

Q. Although the L100 inverter is a variable speed drive, can I use it in a fixed-speed application?

A. A fixed speed application usually is a result of cost-sensitivity or negligible benefits if variable speed were used (consumer products are examples). In those cases, the power source connects directly to the motor (no special drive needed). However, using a variable speed drive can benefit many type of industrial and commercial motor applications, by providing controlled acceleration and deceleration, high torque at low speeds, and energy savings over alternative solutions.

Q. Can I use an inverter and AC induction motor in a positioning application?

A. That depends on the required precision, and the slowest speed the motor will must turn and still deliver torque. If you set the torque boost, the L100 can develop starting torque at 100% of its rating. However, DO NOT use an inverter if you need the motor to stop and hold the load position without the aid of a mechanical brake (use a servo or stepper motion control system).

Q. Does the optional digital operator interface or the PC software (DOP Plus) provide features beyond what is available from the keypad on the unit?

A. Yes. However, note first that the same set of parameters and functions are equally accessible from either the unit’s keypad or from remote devices. The DOP Plus PC software lets you save or load inverter configurations to or from a disk file. And, the hand-held digital operator provides hard-wired terminals, a safety requirement for some installations.

Q. Why does the manual or other documentation use terminology such as "200V class" instead of naming the actual voltage, such as "230 VAC?"

A. A specific inverter model is set at the factory to work across a voltage range particular to the destination country for that model. The model specifications are on the label on the side of the inverter. A European 200V class inverter ("EU" marking) has different parameter settings than a USA 200V class inverter ("US" marking). The initialization procedure (see page 6–8) can set up the inverter for European or US commercial voltage ranges.

Q. Why is there not a 100V class version of the L100 inverter, so it would work with a USA 115VAC power source, for example?

A. A 100V version of the L100 may be available in the future. However, most industrial, commercial, or heavy appliance applications use 230VAC in the USA. Also, a built-in advantage is that using the higher voltage means less current to deliver the same amount of power. This allows you to use smaller diameter (and less expensive) wire for power and motor wiring.

Q. I live in a country where the domestic utility power is 115 VAC. Is there a way to conveniently access a 230 VAC power source for a test bench to develop a motor application?

A. A 1:2 step-up transformer is available from a number of sources (check your local electrical supply house). The transformer will be designed to develop 230 VAC from 115 VAC, for example. Be sure the power output rating (kW) of the transformer is greater than 1.73 times the three-phase current of the motor you intend to power. We recommend doing this for motors 1/2 horsepower or smaller, with small loads. For 400 V class inverters, we recommend only using a utility power source of the correct voltage.

Q. Some models of Hitachi inverters will accept either single phase or three-phase power input. How do I know which input power type to use?

A. If three-phase power is conveniently available for your application, we recommend using that (the inverter can develop its three-phase output power most efficiently from three-phase input power). In the absence of three-phase power, you can use a single-phase power source with slightly less efficiency but the power output rating is the same for N models (single or three-phase).

Q. If I decide to use single-phase input power for the inverter, can I also use a single-phase motor?

A. No. All Hitachi inverters develop a variable three-phase output, requiring the use of a three-phase AC induction motor.

Q. Why doesn't the motor have a neutral connection as a return to the inverter?

A. The motor theoretically represents a "balanced Y" load if all three stator windings have the same impedance. The Y connection allows each of the three wires to alternately serve as input or return on alternate half-cycles.

Q. Does the motor need a chassis ground connection?

A. Yes, for several reasons. This is for protection in the event of a short in the motor that puts a live voltage on its housing. Motors and other components

exhibit leakage currents that increase with aging. And, a grounded chassis generally emits less electrical noise than an ungrounded one.

Q. What type of motor is compatible with the Hitachi inverters?

A. **Motor type** – it must be a three phase AC induction motor. Use an inverter-grade motor that has 800V insulation for 200V class inverters, or 1600V insulation for 400V class.
Motor size – In practice, it's better to find the right size motor for your application; then look for the inverter to match the motor.

Q. How many poles should the motor have?

A. Using a four-pole motor will work for most applications. The greater the number of poles, the slower the top motor speed will be, but it will have higher torque at the slowest speed.

Q. Will I be able to add dynamic (resistive) braking to my Hitachi L100 drive after the initial installation?

A. Yes. You can connect a dynamic braking unit to the L100 inverter. The resistor in the braking unit must be sized to meet the braking requirements.

Q. How will I know if my application will require resistive braking?

A. For new applications, it may be difficult to tell before you actually test a motor/drive solution. In general, some applications can rely on system losses such as friction to serve as the decelerating force, or otherwise can tolerate a long deceleration time. These applications will not need dynamic braking. However, applications with a combination of a high-inertia load and a required short decel time will need dynamic braking. This is a physics question that may be answered either empirically or through extensive calculations.

Q. Several options related to electrical noise suppression are available for the Hitachi inverters. How can I know if my application will require any of these options?

A. The purpose of these noise filters is to reduce the inverter electrical noise so the operation of nearby electrical devices is not affected. Some applications are governed by particular regulatory agencies, and noise suppression is mandatory. In those cases, the inverter must have the corresponding noise filter installed. Other applications may not need noise suppression, unless you notice electrical interference with the operation of other devices.

Q. The L100 features a PID loop feature. PID loops are usually associated with chemical processes, heating, or process industries in general. How could the PID loop feature be useful in my application?

A. You will need to determine which main variable in your application the motor affects. That is the process variable (PV) for the motor. Over time, a faster motor speed will cause a faster change in the PV than a slow motor speed will. By using the PID loop feature, the inverter commands the motor to run at the optimal speed required to maintain the PV at the desired value for current conditions. Using the PID loop feature will require an additional sensor and other wiring, and is considered an advanced application.

Inverter Mounting and Installation

2

In This Chapter.... page

Orientation to Inverter Features

Unpacking and Inspection

Please take a few moments to unpack your new L100 inverter and perform these steps:

1. Look for any damage that may have occurred during shipping.
2. Verify the contents of the box include:
   a. One L100 inverter
   b. One Instruction Manual with self-adhesive label for the inverter
   c. One L100 Quick-reference Guide
   d. One packet of desiccant — discard (not for human consumption)
3. Inspect the specifications label on the side of the inverter. Make sure it matches the product part number you ordered.

Main Physical Features

The L100 Series inverters vary in size according to the current output rating and motor size for each model number. All feature the same basic keypad and connector interface for consistent ease of use. The inverter construction has a heat sink at the back of the housing. The larger models include a fan(s) to enhance heat sink performance. The mounting holes are pre-drilled in the heat sink for your convenience. Never touch the heat sink during or just after operation; it can be very hot.

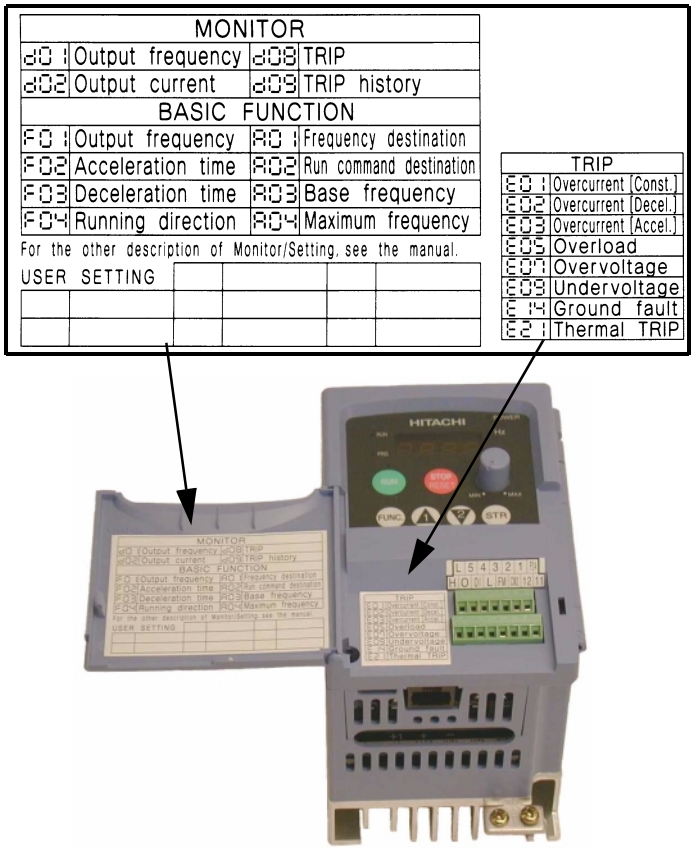
The electronics housing and front panel are built onto the front of the heat sink. The front panel has three levels of physical access designed for convenience and safety:

- **First-level access** – for basic use of inverter during powered operation (power is On)
- **Second-level access** – for editing parameters and wiring control signals (power is On)
- **Third-level access** – for wiring the inverter power supply or motor (power is OFF)

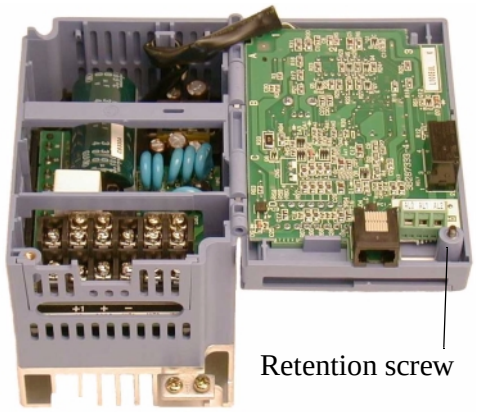
1. **First-level Access** - View the unit just as it came from the box as shown. The four-digit display can show a variety of performance parameters. LEDs indicate whether the display units are Hertz or Amperes. Other LEDs indicate Power (external), and Run/ Stop Mode and Program/Monitor Mode status. Membrane keys Run and Stop/Reset, and a Min/Max frequency control knob control motor operation. These controls and indicators are usually the only ones needed after the inverter installation is complete. You can also access the modular jack for connecting a programming or monitoring device such as a PC (see Chapter 3). And, you can access the two chassis GND screws on the metal tab at the bottom of the inverter.

2. **Second-level access** - Locate the lift tab at the right lower corner of the front panel near the safety warning message. Lift the corner to swing the half-door around to the left. This exposes four more control buttons and some connectors.
The FUNC., ▲1, ▽2, and STR keys allow an operator to access and change the inverter's functions and parameter values. The 7 and 8-position connectors provide the interface for logic-level control signals. These signals are generally low-voltage in nature and are appropriate for second-level access.

Locate the label sheet that came with the manual. This is a good moment to apply the self-sticking labels as shown below. Adhere the larger label for monitor codes and basic functions to the rear of the half-door panel. Then adhere the remaining trip code label to the area beside the connectors. Be careful not to cover the screw access on models like the one shown.

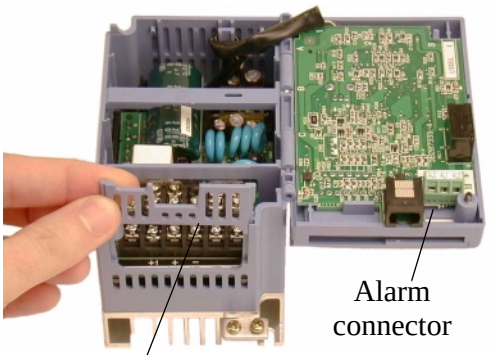


3. **Third-level access** - First, ensure no power source of any kind is connected to the inverter. If power has been connected, wait five minutes after powerdown and verify the Power LED is off to proceed. Then locate the recessed retention screw on the left side main front panel (it is along the left hinge area on some models, or behind the first access door on others). Use a small screwdriver (Regular or Phillips) to loosen the screw. Swing the door around to the left to reveal the internal components of the drive. The two-level tiered 12-position terminal block accepts wires for the power input and wires to the motor.

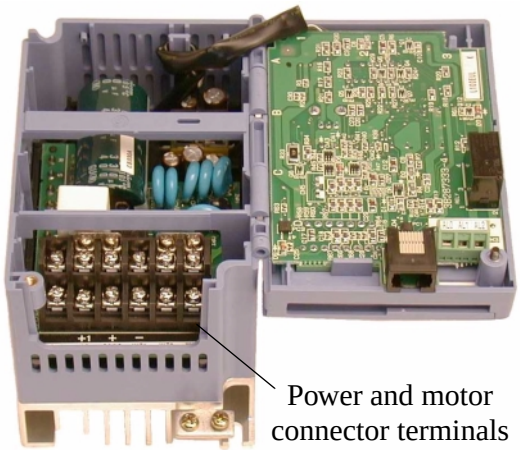


Notice the housing partition that lifts out to allow full access to the terminals for wiring as shown. Never operate the inverter drive with the partition removed or the full access door opened.

The alarm circuit connections are accessible on the 3-position connector near the modular connector on the rear of the main panel door. The nearby relay provides both normally-open and normally-closed logic for interface to an external alarm. The alarm circuit may carry hazardous live voltages even when the main power to the inverter is off. So, never directly touch any component on the circuit board in the panel door. A notch in the removable partition serves as the exit path for alarm circuit wiring.

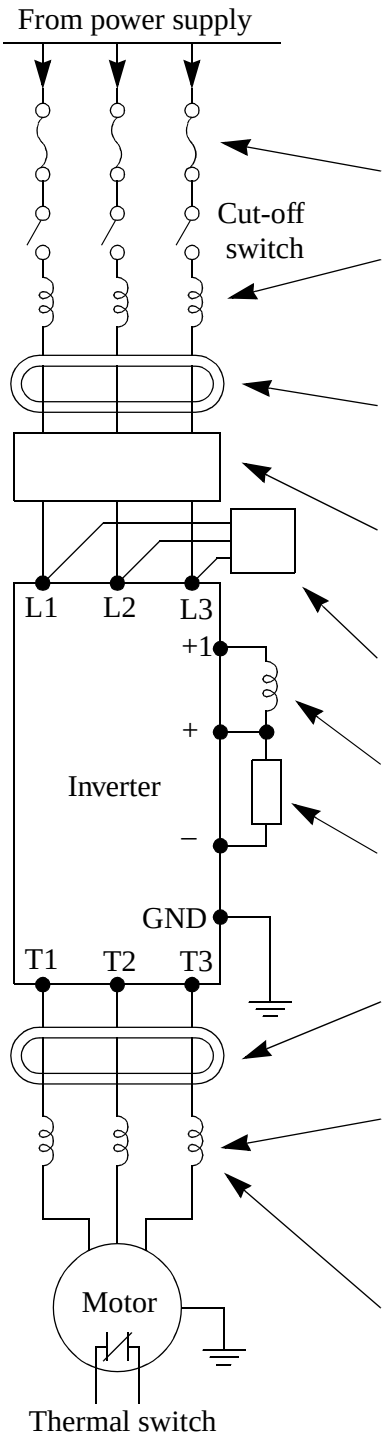


The following sections will describe the system design and guide you through a step-by-step installation process. After the section on wiring, this chapter will show how to use the front panel keys to access functions and edit parameters.



Basic System Description

A motor control system will obviously include a motor and inverter, as well as fuses for safety. If you are connecting a motor to the inverter on a test bench just to get started, that's all you may need for now. But a system can also have a variety of additional components. Some can be for noise suppression, while others may enhance the inverter's braking performance. The figure and table below show a system with all the optional components you may need in your finished application.



Name	Function
Fuse	Current overload protection for power supply and wiring.
Input-side AC Reactor	This is useful in suppressing harmonics induced on the power supply lines, or when the main power voltage imbalance exceeds 3% (and power source capacity is more than 500 kVA), or to smooth out line fluctuations. It also improves the power factor.
Radio noise filter	Electrical noise interference may occur on nearby equipment such as a radio receiver. This magnetic choke filter helps reduce radiated noise (can also be used on output).
EMI filter (for CE applications)	Reduces the conducted noise on the power supply wiring generated by the main power supply to protect the inverter. Connect to the inverter primary (input side).
Radio noise filter (use in non-CE applications)	This capacitive filter reduces radiated noise from the main power wires in the inverter input side.
DC link choke	Suppresses harmonics generated by the inverter. However, it will not protect the input diodes.
Dynamic braking unit & resistor	This is useful for increasing the inverter's control torque for high duty-cycle (on-off) applications, and improving the decelerating capability.
Radio noise filter	Electrical noise interference may occur on nearby equipment such as a radio receiver. This magnetic choke filter helps reduce radiated noise (can also be used on input).
AC reactor	This reactor reduces the vibrations in the motor caused by the inverter's switching waveforms, by smoothing the waveforms to approximate commercial power quality. It is also useful when wiring from the inverter to the motor is more than 10m in length, to reduce harmonics.
LCR filter	Sine wave shaping filter for output side.

Note that some components are required for regulatory agency compliance (see Chapter 5).

Step-by-Step Basic Installation

This section will guide you through the following basic steps of installation:

1. Study the warnings associated with mounting the inverter.

2. Select a suitable mounting location.

3. Place covers over the inverter's ventilation openings to prevent debris from entering.

4. Check the inverter mounting dimensions for footprint and mounting hole locations.

5. Study the caution and warning messages associated with wiring the inverter.

6. Connect wiring for the inverter power input.

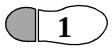
7. Connect wiring to the motor.

8. Remove any covers applied in Step 3 from the inverter's ventilation openings.

9. Perform a powerup test.

10. Make observations and check your installation.

Choosing a Mounting Location



Step 1: Study the following caution messages associated with mounting the inverter. This is the time when mistakes are most likely to occur that will result in expensive rework, equipment damage, or personal injury.

CAUTION: Be sure to install the unit on flame-resistant material such as a steel plate. Otherwise, there is the danger of fire.

CAUTION: Be sure not to place any flammable materials near the inverter. Otherwise, there is the danger of fire.

CAUTION: Be sure not to let the foreign matter enter vent openings in the inverter housing, such as wire clippings, spatter from welding, metal shavings, dust, etc. Otherwise, there is the danger of fire.

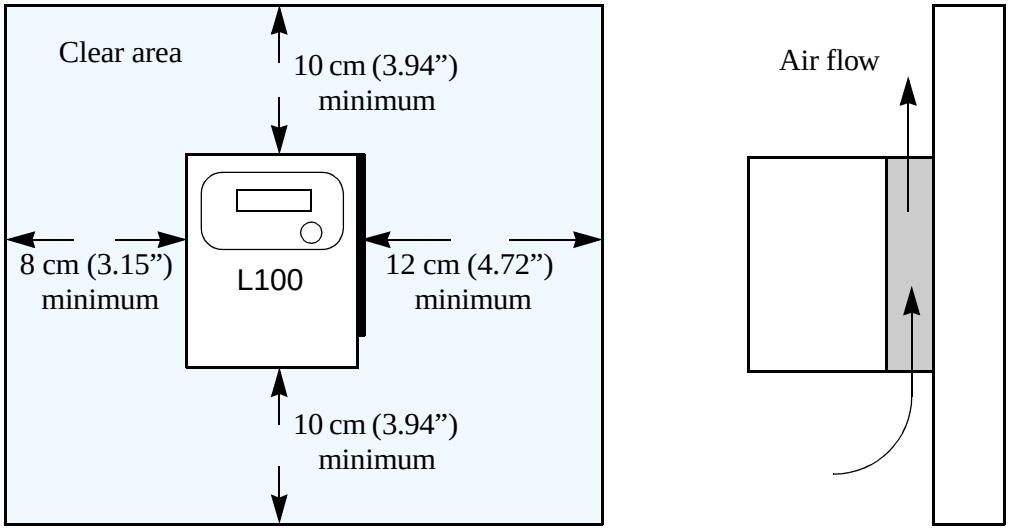
CAUTION: Be sure to install the inverter in a place which can bear the weight according to the specifications in the text (Chapter 1, Specifications Tables). Otherwise, it may fall and cause injury to personnel.

CAUTION: Be sure to install the unit on a perpendicular wall which is not subject to vibration. Otherwise, it may fall and cause injury to personnel.

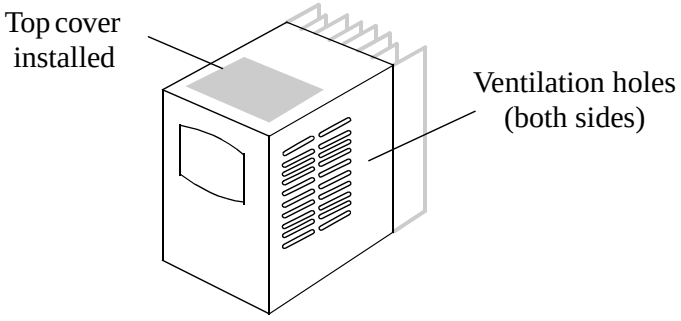
CAUTION: Be sure not to install or operate an inverter which is damaged or has missing parts. Otherwise, it may cause injury to personnel.

CAUTION: Be sure to install the inverter in a well-ventilated room which does not have direct exposure to sunlight, a tendency for high temperature, high humidity or dew condensation, high levels of dust, corrosive gas, explosive gas, inflammable gas, grinding-fluid mist, salt damage, etc. Otherwise, there is the danger of fire.

Step 2: To summarize the caution messages — you will need to find a solid, non-flammable, vertical surface that is a relatively clean and dry environment. In order to ensure enough room for air circulation around the inverter to aid in cooling, maintain the specified clearance around the inverter specified in the diagram.



Step 3: Before proceeding to the wiring section, it’s a good time to *temporarily* cover the inverter’s ventilation openings. Paper and masking tape is all that is needed to do this. It will prevent harmful debris such as wire clippings and metal shavings from entering the inverter during installation. The inverter housing comes from the factory with a snap-in cover on the top of its housing. Ensure it is in place at this time (also to be removed later, unless the installation must have a NEMA rating).



Please observe this checklist while mounting the inverter:

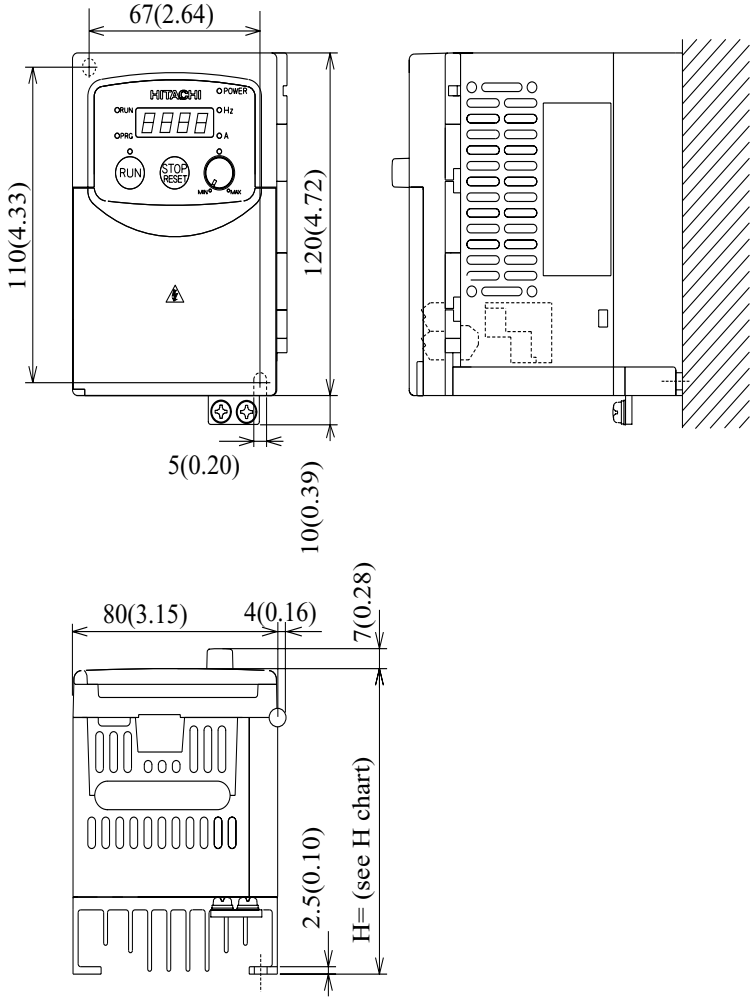
1. The ambient temperature must be in the range of -10 to 40°C. If the range will be up to 50°C, you will need to set the carrier frequency to 2.1 kHz or less and derate the output current to 80% or less. Chapter 3 covers how to change parameters such as the carrier frequency. Remember to remove the top cover (unless the installation is to have a NEMA rating)!
2. Keep any other heat-producing equipment as far away from the inverter as possible.
3. When installing the inverter in an enclosure, maintain the clearance around the inverter and verify that its ambient temperature is within specification when the enclosure door is closed.
4. Do not open the main front panel door at any time during operation.

Inverter Dimensions for Mounting

Step 4: Locate the applicable drawing on the following pages for your inverter. Dimensions are given in millimeters (inches) format.

External Dimensions

	MODEL	H mm (in.)
L100	-002NFE	107 (4.21)
	-002NFU	107 (4.21)
	-004NFE	107 (4.21)
	-004NFU	107 (4.21)



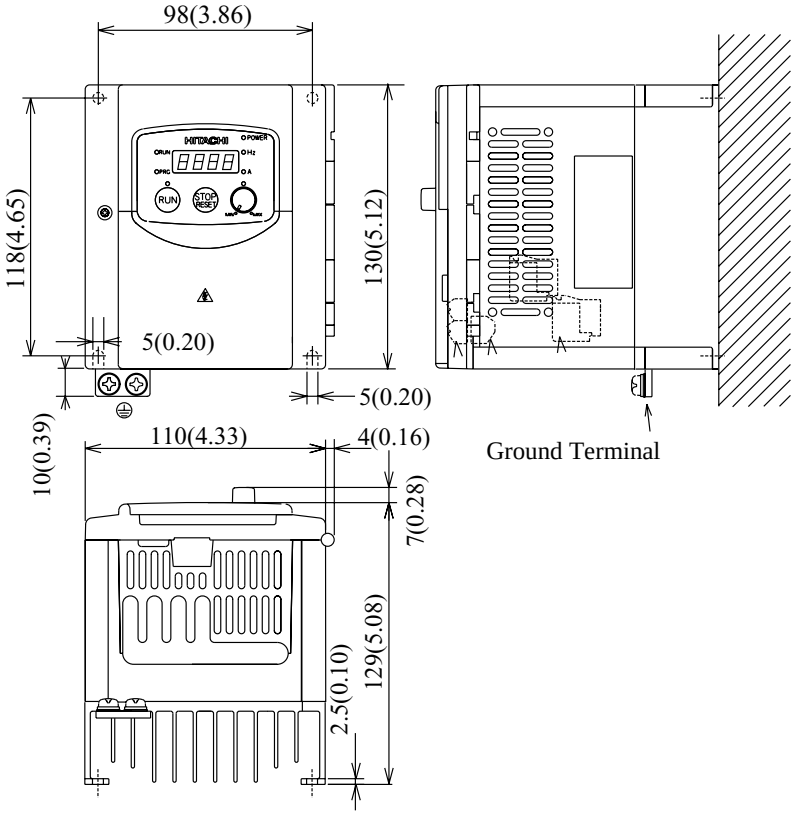
NOTE: Some inverter housings require two mounting screws, while others require four. Be sure to use lock washers or other means to ensure screws do not loosen due to vibration.

Dimensional drawings continued...

External Dimensions

MODEL

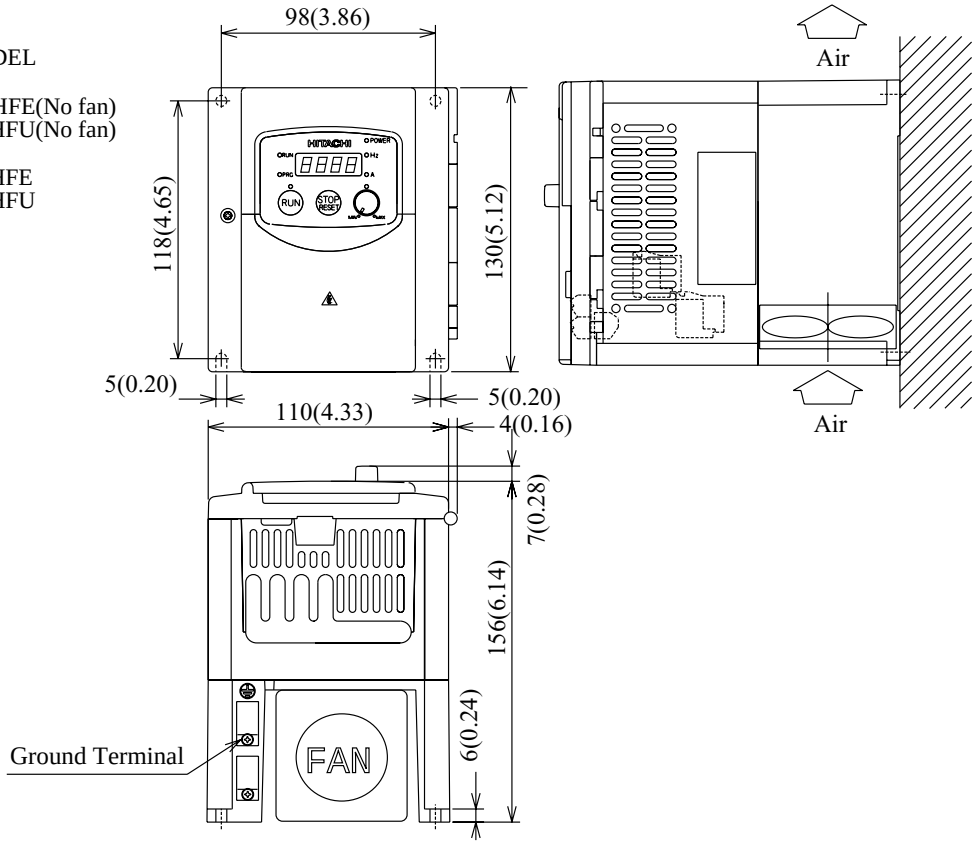
L100 -004HFE
-004HFU
-005NFE
-007NFE
-007NFU



MODEL

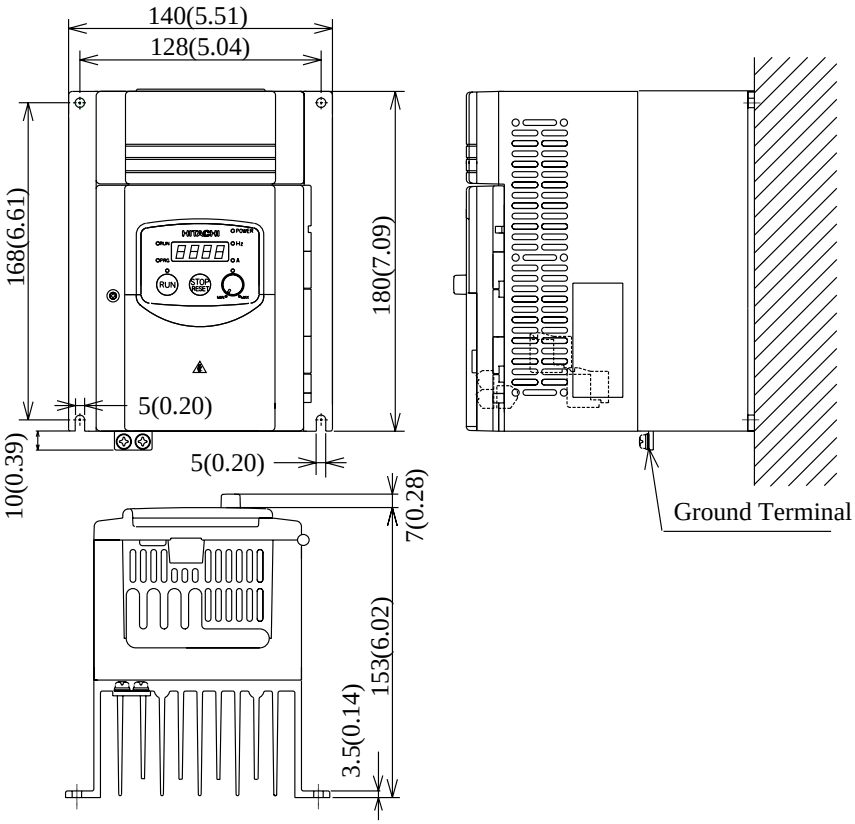
L100 -007HFE(No fan)
-007HFU(No fan)

-015HFE
-015HFU



Dimensional drawings continued...

L100 -011NFE
-015NFE
-015NFU

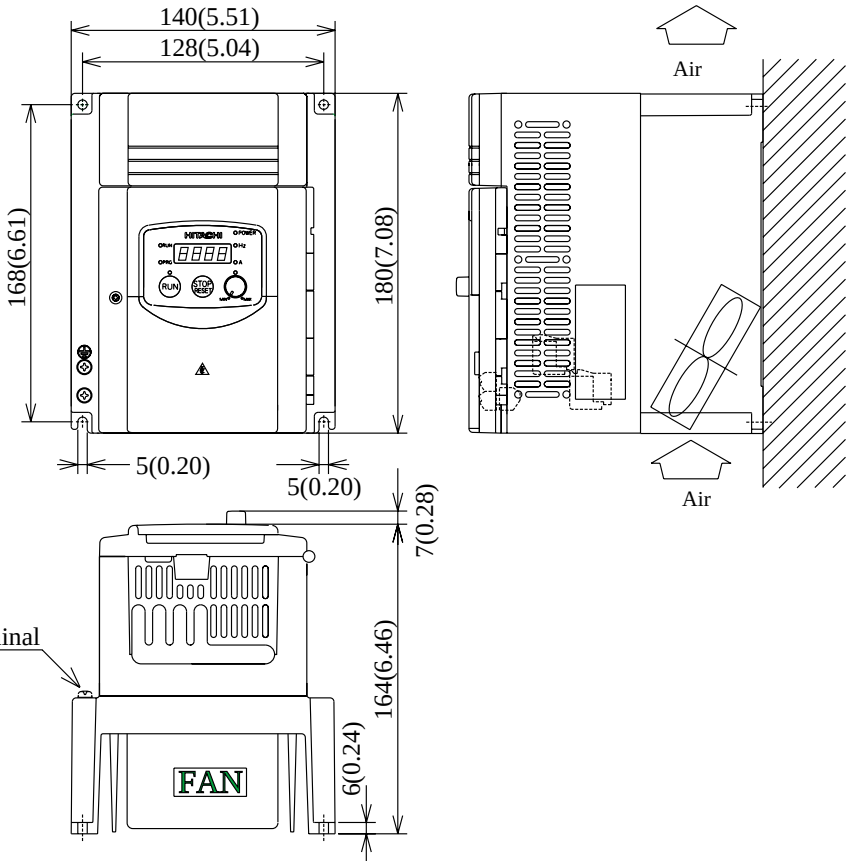


L100 -022NFE
-022NFU

-022HFE
-022HFU

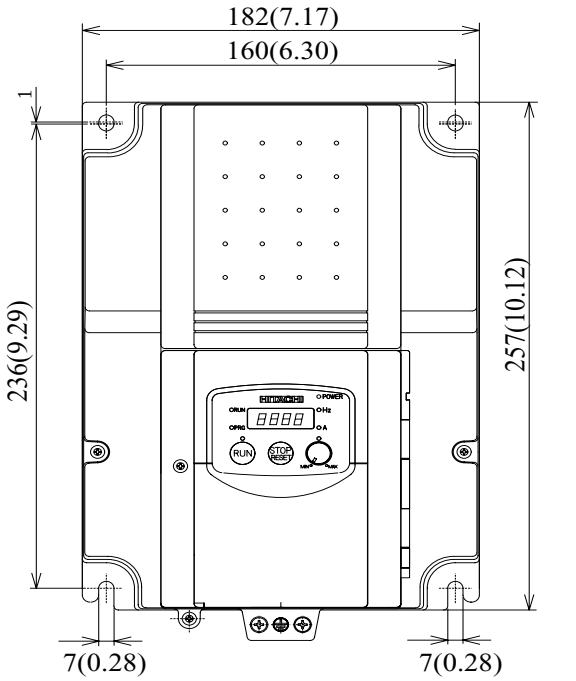
-030HFE
-037LFU

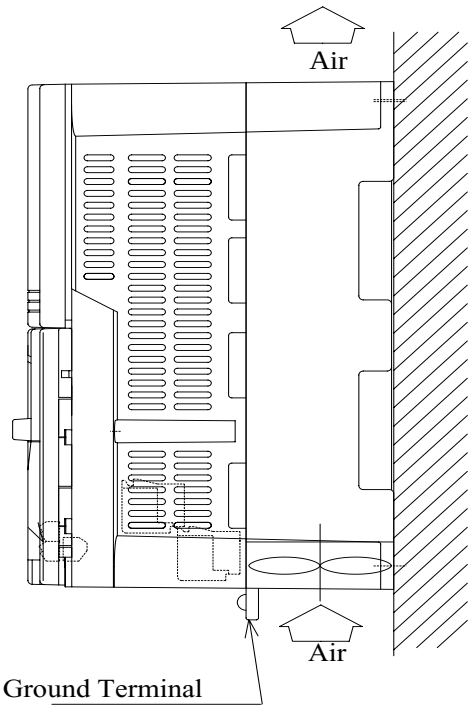
-040HFE
-040HFU

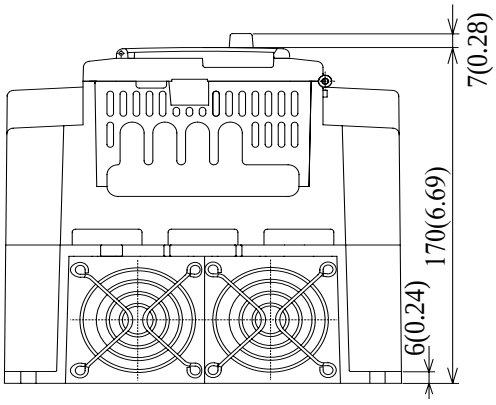


Dimensional drawings continued...

L100 -055LFU
-075LFU
-055HFU
-075HFU
-055HFE
-075HFE







NOTE: Model L100-075LFU has (2) fans. All other models in this housing have (1) fan.

Preparation for Wiring

Step 5: It is very important to perform the wiring steps carefully and correctly. Before proceeding, please study the caution and warning messages below.

WARNING: "Use 60/75°C Cu wire only" or equivalent.

WARNING: "Open Type Equipment."

WARNING: "A Class 2 circuit wired with Class 1 wire" or equivalent.

WARNING: "Suitable for use on a circuit capable of delivering not more than 5,000 rms symmetrical amperes, 240 V maximum." For models with suffix N or L.

WARNING: "Suitable for use on a circuit capable of delivering not more than 5,000 rms symmetrical amperes, 480 V maximum." For models with suffix H.

HIGH VOLTAGE: Be sure to ground the unit. Otherwise, there is a danger of electric shock and/or fire.

HIGH VOLTAGE: Wiring work shall be carried out only by qualified personnel. Otherwise, there is a danger of electric shock and/or fire.

HIGH VOLTAGE: Implement wiring after checking that the power supply is off. You may incur electric shock and/or fire.

HIGH VOLTAGE: Do not connect wiring to an inverter or operate an inverter that is not mounted according the instructions given in this manual. Otherwise, there is a danger of electric shock and/or injury to personnel.

Determination of Wire and Fuse Sizes

The maximum motor currents in your application determines the recommended wire size. The following table gives the wire size in AWG. The "Power Lines" column applies to the inverter input power, output wires to the motor, the earth ground connection, and any other component shown in the system wiring diagram on page 2–5. The "Signal Lines" column applies to any wire connecting to the two green 7 and 8-position connectors just inside the front panel half-door.

Motor Output (kW/HP)		Inverter Model	Wiring		Applicable equipment
kW	HP		Power Lines	Signal Lines	Fuse (class J) rated 600V
0.2	1/4	L100-002NFE/NFU	AWG16 / 1.3 mm^2	(*) 18 to 28 AWG / 0.14 to 0.75 mm^2 shielded wire	10A
0.4	1/2	L100-004NFE/NFU			
0.55	3/4	L100-005NFE			
.75	1	L100-007NFE/NFU	AWG14 / 2.1 mm^2		15A
1.1	1 1/2	L100-011NFE			
1.5	2	L100-015NFE/NFU	AWG12 / 3.3 mm^2		20 A (single ph.) 15A (three ph.)
2.2	3	L100-022NFE/NFU	AWG10 / 5.3 mm^2		30A (single ph.) 20A (three ph.)
3.7	5	L100-037LFU	AWG12 / 3.3 mm^2		30A
5.5	7 1/2	L100-055LFU	AWG10 / 5.3 mm^2		40A
7.5	10	L100-075LFU	AWG8 / 8.4 mm^2		50A
0.4	1/2	L100-004HFE/HFU	AWG16 / 1.3 mm^2		3A
0.75	1	L100-007HFE/HFU			6A
1.5	2	L100-015HFE/HFU			10A
2.2	3	L100-022HFE/HFU			
3.0	4	L100-030HFE	AWG14 / 2.1 mm^2		15A
4.0	5	L100-040HFE/HFU			
5.5	7 1/2	L100-055HFE/HFU	AWG12 / 3.3 mm^2		20A
7.5	10	L100-075HFE/HFU			25A

Note 1: Field wiring must be made by a UL-listed and CSA-certified closed-loop terminal connector sized for the wire gauge involved. Connector must be fixed by using the crimping tool specified by the connector manufacturer.

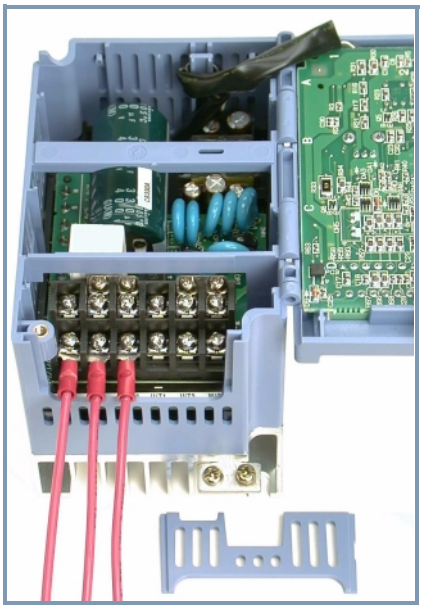
Note 2: Be sure to consider the capacity of the circuit breaker to be used.

Note 3: Be sure to use larger wires for the power lines if the distance exceeds 20 meters.

(*) Use 18 AWG / 0.75 mm^2 wire for the alarm signal wire (AL0, AL1, AL2 terminals).

Wiring the Inverter Input to a Power Supply

Step 6: In this step, you will connect wiring to the input of the inverter. First, you must determine whether the inverter model you have requires three-phase power only, or if it can accept either single-phase or three-phase power. All models have the same power connector terminals labeled **L1, L2, and L3/N. So, you must refer to the specifications label (on the side of the inverter) for the acceptable power source types! For inverters which can accept single-phase power and are connected that way, terminal L2 will remain unconnected.** The wiring example to the right shows an L100 inverter wired for 3-phase input. Note the use of spade lug connectors for a secure connection.

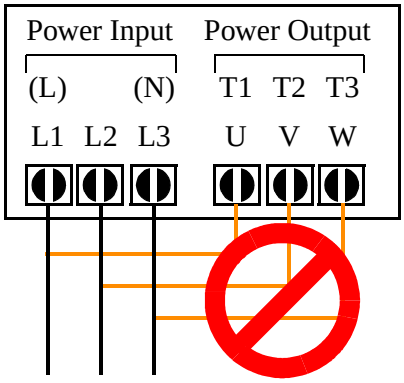


NOTE: An inverter powered by a portable power generator may receive a distorted power waveform, overheating the generator. In general, the generator capacity should be five times that of the inverter (kVA) in a PWM (pulse-width modulated) control system, or six times greater in a PAM (pulse-amplitude modulated) control system.

CAUTION: Be sure that the input voltage matches the inverter specifications:
- Single/Three phase 200 to 240 V 50/60 Hz (up to 2.2kW)
- Three phase 200 to 230V 50/60Hz (above 2.2kW)
- Three phase 380 to 460 V 50/60Hz

CAUTION: Be sure not to input a single phase to a three-phase-only type inverter. Otherwise, there is the danger of fire.

CAUTION: Be sure not to connect an AC power supply to the output terminals. Otherwise, there is the danger of injury and/or fire.



NOTE:
L, N: Single-phase 200 to 240V 50/60 Hz
L1, L2, L3: Three-phase 200 to 230V 50/60 Hz
Three-phase 380 to 460V 50/60 Hz

CAUTION: Fasten the screws with the specified fastening torque (see the following table). Check for any loosening of screws. Otherwise, there is the danger of fire.

CAUTION: Remarks for using earth leakage circuit breakers in the mains supply: Frequency inverters with CE-filters (RFI-filter) and shielded (screened) motor cables have a higher leakage current toward Earth GND. Especially at the moment of switching on this can cause inadvertent tripping of earth leakage circuit breakers. Because of the rectifier on the input side of the inverter there is the possibility to stall the switch-off function through small amounts of DC current. Please observe the following:

- Use only short time-invariant and pulse current-sensitive earth leakage circuit breakers with higher trigger current.
- Other components should be secured with separate earth leakage circuit breakers.
- Earth leakage circuit breakers in the power input wiring of an inverter are not an absolute protection against electric shock by direct touching.

CAUTION: Be sure to install a fuse in the wire for each phase of the main power supply to the inverter. Otherwise, there is the danger of fire.

CAUTION: For motor leads, earth leakage breakers and electromagnetic contactors, be sure to size these components properly (each must have the capacity for rated current and voltage). Otherwise, there is the danger of fire.

Terminal Dimensions and Tightening Torque

The terminal screw dimensions for all L100 inverters are listed in table below. This information is useful in sizing spade lug or ring lug connectors for wire terminations.

Connector	Number of Screw Terminals	Models 002NF, 004NF, 005NF		Models 007NF–022NF, 037LF, 004HF–075HF	
		Screw Diameter	Width (mm)	Screw Diameter	Width(mm)
Power Terminals	12	M3.5	7.1	M4	9
Control Signal	15	M2	–	M2	–
Alarm Signal	3	M3	–	M3	–
Ground Terminals	2	M4	–	M4	–

When connecting wiring, use the tightening torque listed in the following table to safely attach wiring to the connectors.

Screw	Tightening Torque	Screw	Tightening Torque
M2	0.2 N•m (max. 0.25 N•m)	M3.5	0.8 N•m (max. 0.9 N•m)
M3	0.5 N•m (max. 0.6 N•m)	M4	1.2 N•m (max. 1.3 N•m)

Wiring the Motor to the Inverter Output

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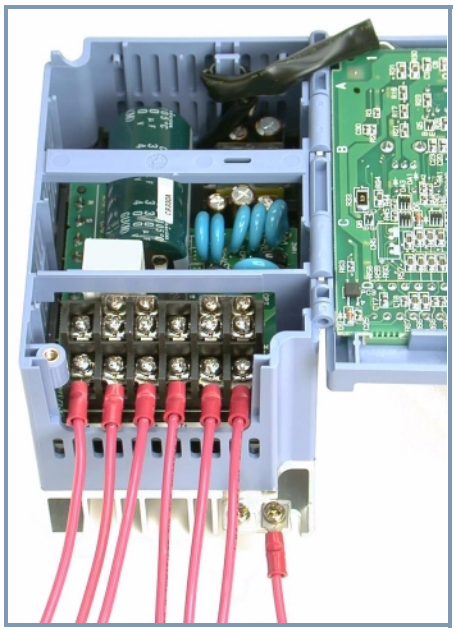
Step 7: The process of motor selection is beyond the scope of this manual. However, it must be an AC induction motor with three phases. It should also come with a chassis ground lug. If the motor does not have three power input leads, stop the installation and verify the motor type. Other guidelines for wiring the motor include:

- Use an inverter-grade motor for maximum motor life (1600V insulation).
- For standard motors, use the AC reactor accessory if the wiring between the inverter and motor exceeds 10 meters in length.

Simply connect the motor to the terminals indicated on the inverter to the right. The terminals are labeled U/T1, V/T2, and W/T3. This is a good time to connect the chassis ground lug on the drive as well. The motor chassis ground must also connect to the same point. Use a star ground (single-point) arrangement, and never daisy-chain the grounds (point-to-point).



To Power Supply | To Motor | To Chassis Ground

Use the same wire gauge on the motor and chassis ground wiring as you used on the power input wiring in the previous step. After completing the wiring:

- Replace the housing partition that covers access to the power connections.
- Close the main door and secure the retention screw firmly.

Other Wiring - After the initial installation and powerup test, you may need to wire the remaining connectors — the control signal connector, and the alarm circuit connector. This is covered in detail on page 4–22.

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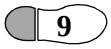
Step 8: After mounting and wiring the inverter, it's time to remove any covers from the inverter housing. This includes covers over the side ventilation ports. Remove the square cover panel at the top of the housing, unless the application must maintain a NEMA rating.

WARNING: Make sure the input power to the inverter is off. If the drive has been powered, leave it off for five minutes before continuing.

The top housing cover is held in place by four locking tabs. To remove the cover, squeeze two corners together and push a small screwdriver under one side as shown, while pulling upward. Hold the screwdriver at the angle shown, and DO NOT push the screwdriver or any object through ventilation openings and into the inverter.

Powerup Test



Step 9: After wiring the inverter and motor, you're ready to do a powerup test. The procedure that follows is designed for the first-time use of the drive. Please verify the following conditions before conducting the powerup test:

- You have followed all the steps in this chapter up to this step.
- The inverter is new, and is securely mounted to a non-flammable vertical surface
- The inverter is connected to a power source and motor.
- No additional wiring of inverter connectors or terminals has been done.
- The power supply is reliable, and the motor is a known working unit.
- The motor is securely mounted, and is not connected to any load.

Goals for the Powerup Test

If there are any exceptions to the above conditions at this step, please take a moment to take any measures necessary to reach this basic starting point. The specific goals of this powerup test are:

1. Verify that the wiring to the power supply and motor is correct.
2. Demonstrate that the inverter and motor are generally compatible.
3. Give a brief introduction to the use of the built-in operator keypad.

The powerup test gives you an important starting point to ensure a safe and successful application of the Hitachi inverter. We highly recommend performing this test before proceeding to the other chapters in this manual.

Pre-test and Operational Precautions

The following instructions apply to the powerup test, or to any time the inverter is powered and operating. Please study the following instructions and messages before proceeding with the powerup test.

1. The power supply must have fusing suitable for the load. Check the fuse size chart presented in Step 5, if necessary.
2. Be sure you have access to a cut-off switch for the drive input power if necessary. However, do not turn off power to the inverter during its operation unless it is an emergency.
3. Turn the inverter's front panel potentiometer to the *MIN* position (fully counter-clockwise).

CAUTION: The heat sink fins will have a high temperature. Be careful not to touch them. Otherwise, there is the danger of getting burned.

CAUTION: The operation of the inverter can be easily changed from low speed to high speed. Be sure check the capability and limitations of the motor and machine before operating the inverter. Otherwise, there is the danger of injury.

CAUTION: If you operate a motor at a frequency higher than the inverter standard default setting (50Hz/60Hz), be sure to check the motor and machine specifications with the respective manufacturer. Only operate the motor at elevated frequencies after getting their approval. Otherwise, there is the danger of equipment damage.

CAUTION: Check the following before and during the powerup test. Otherwise, there is the danger of equipment damage.

- Is the shorting bar between the +1 and + terminals installed? DO NOT power or operate the inverter if the jumper is removed.
- Is the direction of the motor correct?
- Did the inverter trip during acceleration or deceleration?
- Were the rpm and frequency meter readings as expected?
- Were there any abnormal motor vibrations or noise?

Powering the Inverter

If you have followed all the steps, cautions and warnings up to this point, you're ready to apply power. After doing so, the following events should occur:

- The *POWER* LED will illuminate.
- The numeric (7-segment) LEDs will display a test pattern, then stop at `0.0`.
- The *Hz* LED will be on.

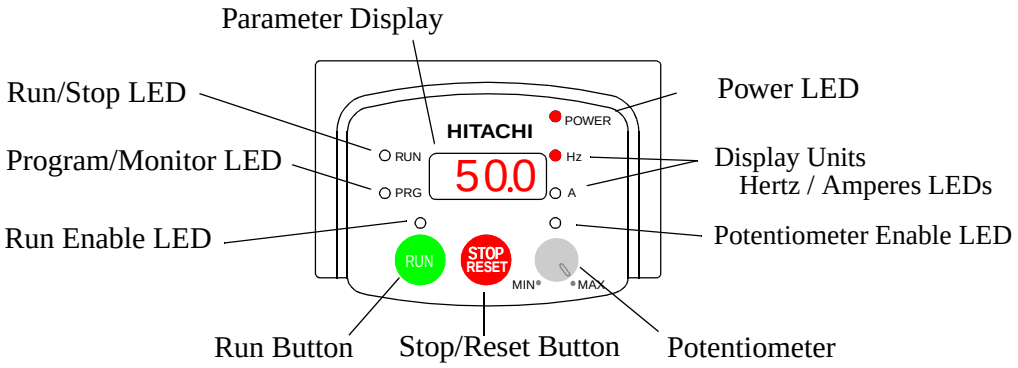
If the motor starts running unexpectedly or any other problem occurs, press the *STOP* button. Only if necessary should you remove power to the inverter as a remedy.

NOTE: If the inverter has been previously powered and programmed, the LEDs (other than the POWER LED) may illuminate differently than as indicated above. If necessary, you can initialize all parameters to the factory default settings. See the initialization instructions on page 6–8.

Using the Front Panel Keypad

Front Panel Introduction

Please take a moment to familiarize yourself with the keypad layout shown in the figure below. These are the visible controls and indicators when the front panel door is closed.



The display is used in programming the inverter's parameters, as well as monitoring specific parameter values during operation. Many functions are applicable only during the initial installation, while others are more useful for maintenance or monitoring.

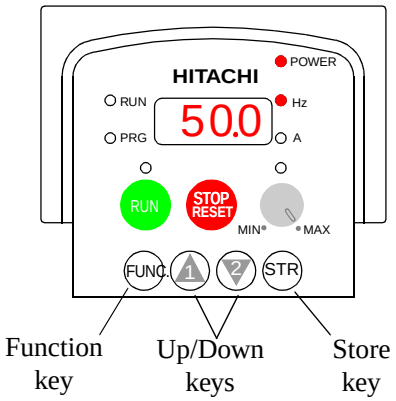
Parameter Editing Controls

Now, open the front panel (half-door) for second-level access to reveal additional operator keys for parameter editing as shown below. In normal operation after installation, parameter editing is unnecessary, so these controls are hidden from view.

The front panel controls and indicators are described as follows:

- **Run/Stop LED** - On when the inverter output is running the motor (Run Mode), and Off when the inverter output is Off (Stop Mode).
- **Program/Monitor LED** - This LED is On when the inverter is ready for parameter editing (Program Mode). It is Off when the parameter display is monitoring data (Monitor Mode).
- **Run Enable LED** - is On when the inverter is ready to respond to the Run command, Off when the Run command is disabled.
- **Run Key** - Press this key to run the motor (the Run Enable LED must be On first).
- **Stop/Reset Key** - Press this key to stop the motor when it is running (uses the programmed deceleration rate). This key will also reset an alarm which has tripped.
- **Potentiometer** - allows an operator to enter data for selecting a scalar value from a range, associated with the inverter output frequency.
- **Potentiometer Enable LED** - On when the potentiometer is enabled for value entry.
- **Parameter Display** - a 4-digit, 7-segment display for parameters and function codes.
- **Display Units, Hertz/Amperes** - One of these LEDs will be On to indicate the units associated with the parameter display.
- **Power LED** - This LED is On when the power input to the inverter is on.

- **Function Key** - This key is used to navigate through the lists of parameters and functions for setting and monitoring parameter values.
- **Up/Down (▲1, ▼2) Keys** - Use these keys alternately to move up or down the lists of parameter and functions shown in the display, and increment/decrement values.
- **Store (STR) Key** - When the unit is in Program Mode and the operator has edited a parameter value, press the Store key to write the new value to the EEPROM.



Keys, Modes, and Parameters

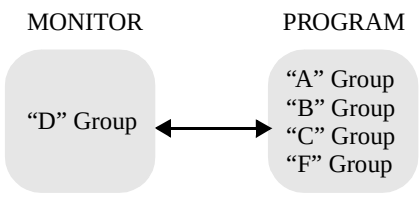
Purpose of the keypad is to provide a way to change modes and parameters. The term *function* applies to both monitoring modes and parameters. These are all accessible through *function codes*, which are primarily 3-character codes. The various functions are separated into related groups identifiable by the left-most character, as the table shows.

Function Group	Type (Category) of Function	Mode to Access	PGM LED Indicator
"D"	**Monitoring functions**	Monitor	○
"F"	**Basic profile parameters**	Program	●
"A"	**Standard functions**	Program	●
"B"	**Fine tuning functions**	Program	●
"C"	**Intelligent terminal functions**	Program	●
"E"	**Error codes**	—	—

For example, function "A 04" is the *base frequency setting* for the motor, typically 50 Hz or 60 Hz. To edit the parameter, the inverter must be in Program Mode (PGM LED will be On). You use the front panel keys to first select the function code "A 04." After displaying the value for "A 04," use the Up/Down (▲1 or ▼2) keys to edit the value.

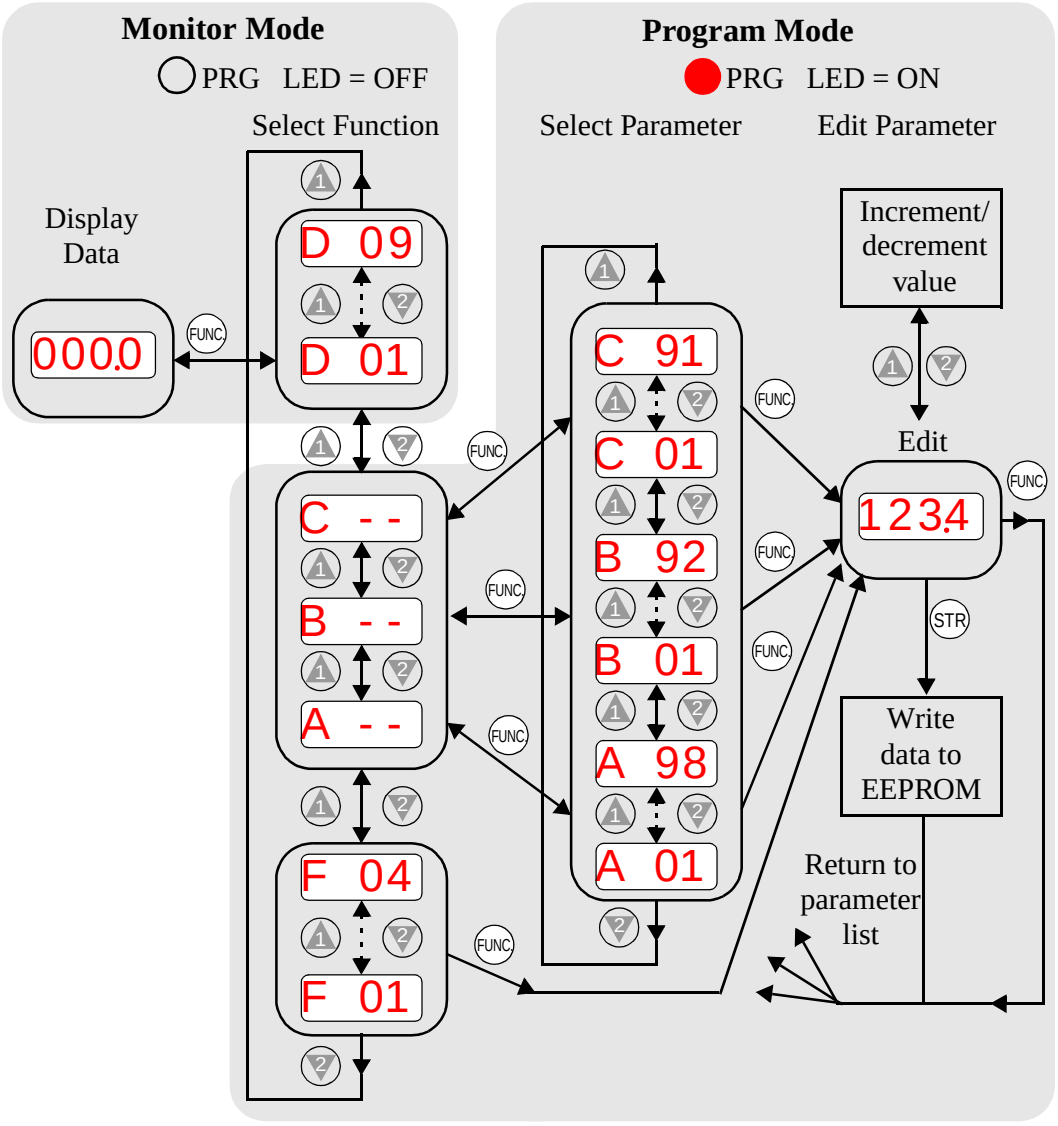
NOTE: The inverter 7-segment display shows lower case "b" and "d", which means the same as the upper case letters "B" and "D" used in this manual (for uniformity "A to F").

The inverter automatically switches into Monitor Mode when you access "D" group functions. It switches into Program Mode when you access any other group, because they all have editable parameters. Error codes use the "E" group, and appear automatically when a fault event occurs. Refer to page 6–5 for error code details.

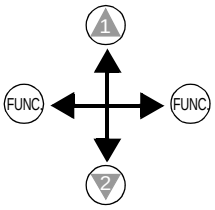


Keypad Navigational Map

The L100 Series inverter drives have many programmable functions and parameters. Chapter 3 will cover these in detail, but we need to access just a few items to perform the powerup test. The menu structure makes use of function codes and parameter codes to allow programming and monitoring with only a 4-digit display and a few buttons and LEDs. So, it is important to become familiar with the basic navigational map of parameters and functions in the diagram below. You may later use this map as a reference.



The navigational map shows the relationship of all resources of the inverter in one view. In general, use the FUNC key to move left and right, and the ▲1 ▽2 (arrow) keys to move up and down. Other tables in this chapter will show how to set up a particular parameter, for example. However, the map above gives the "big picture" for functions in general.



Selecting Functions and Editing Parameters

In order to run the motor for the powerup test, this section will show how to:

- select the inverter's maximum output frequency to the motor
- select the keypad potentiometer as the source of motor speed command
- select the keypad as the source of the RUN command
- enable the RUN command

The following series of programming tables are designed for successive use. Each table uses the previous table's final state as the starting point. Therefore, start with the first and continue programming until the last one. If you get lost or concerned that some of the other parameters settings may be incorrect, refer to the section on restoring factory default settings on page 6–8.

CAUTION: If you operate a motor at a frequency higher than the inverter standard default setting (50Hz/60Hz), be sure to check the motor and machine specifications with the respective manufacturer. Only operate the motor at elevated frequencies after getting their approval. Otherwise, there is the danger of equipment damage.

Setting the Motor Base Frequency -The motor is designed to operate at a specific AC frequency. Most commercial motors are designed for 50/60 Hz operation. First, check the motor specifications. Then follow the steps in the table below to verify the setting or correct for your motor. DO NOT set it for greater than 50/60 Hz unless the motor manufacturer specifically approves operation at the higher frequency.

Action	Display	Func./Parameter
Press the FUNC key.	D 01	Monitor functions
Press the ▲1 or ▽2 keys until ->	A - -	"A" group selected
Press the FUNC key.	A 01	First "A" parameter
Press the ▲1 key twice.	A 03	Base frequency setting
Press the FUNC key.	60 or 50	Default value for base frequency. US = 60 Hz, Europe = 50 Hz.
Press the ▲1 or ▽2 key as needed.	60	Set to your motor specs (your display may be different)
Press the STR key.	A 03	Stores parameter, returns to "A" group list

TIP: If you need to scroll through a function or parameter list, press and hold the ▲1 or ▽2 key to auto-increment through the list.

Select the Potentiometer for Speed Command - the motor speed may be controlled from the following sources:

- Potentiometer on front panel keypad
- Control terminals
- Remote panel

Then follow the steps in the table below to select the potentiometer for the speed command (the table resumes action from the end of the previous table).

Action	Display	Func./Parameter
Press the ▼2 key twice.	A 01	Speed command source setting
Press the FUNC key.	01	0 = potentiometer 1 = control terminals (default) 2 = keypad
Press the ▼2 key.	00	0 = potentiometer (selected)
Press the STR key.	A 01	Stores parameter, returns to “A” group list

Select the Keypad for the RUN Command - the RUN command causes the inverter to accelerate the motor to the selected speed. You can program the inverter to respond to either the control terminal signal or the keypad RUN key.

Follow the steps in the table below to select the front panel RUN key as the source for the RUN Command (the table resumes action from the end of the previous table).

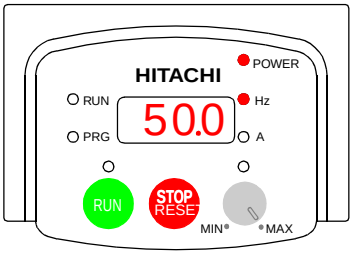
Action	Display	Func./Parameter
Press the ▲1 key.	A 02	Run command source
Press the FUNC key.	01	1 = control terminals (default) 2 = keypad
Press the ▲1 key.	02	2 = keypad (selected)
Press the STR key.	A 02	Stores parameter, returns to “A” group list

NOTE: When you press the STR key in the last step above (and the display = 02), the Run Enable LED above the RUN switch on the keypad will turn ON. This is normal, and does not mean the motor is trying to run. It means that the RUN key is now enabled. DO NOT press the RUN key at this time — finish out the programming exercise first.

TIP: If you became lost during any of these steps, first observe the state of the PRG LED. Then study the keypad navigation on page 21 to determine the current state of the keypad controls and display. As long as you do not press the STR key, no parameters will be changed by keypad entry errors.

Monitoring Parameters with the Display

After using the keypad for parameter editing, it's a good idea to switch the inverter from Program Mode to Monitor Mode and close the panel door (puts the keys for parameter editing out of sight). This will also turn out the PRG LED, and the Hertz or Ampere LED indicates the display units.



For the powerup test, let's monitor the motor speed indirectly by viewing the inverter's output frequency. The *output frequency* must not be confused with *base frequency* (50/60 Hz) of the motor, or the *carrier frequency* (switching frequency of the inverter, in the kHz range). The monitoring functions are in the "D" list, located near the top left of the keypad navigation diagram.

Output frequency (speed) monitor - Resuming the keypad programming from the previous table, follow the steps in the table below.

Action	Display	Func./Parameter
Press the FUNC key.	A - -	"A" group selected
Press the 1 key three times.	d 01	Output frequency selected
Press the FUNC key.	0.0	Output frequency displayed

When the d 01 function code appeared, the PRG LED went off. This confirms the inverter is no longer in programming mode, even while you are selecting the particular monitoring parameter. After pressing the FUN key, the display shows the current speed (which is zero at this point).

Running the Motor

If you have programmed all the parameters up to this point, you're ready to run the motor! First, review this checklist:

1. Verify the Power LED is on. If not, check the power connections.
2. Verify the Run Enable LED is on. If not, review the programming steps to find the problem.
3. Verify the PRG LED is off. If it is on, review the instructions above.
4. Make sure the motor is disconnected from any mechanical load.
5. Turn the potentiometer to the MIN position (completely counter clock-wise).
6. Now, press the RUN key on the keypad. The RUN LED will turn on.
7. Slowly increase the potentiometer setting in clockwise fashion. The motor should start turning when the indicator is in the 9:00 position and beyond.
8. Press the STOP key to stop the motor rotation.

Powerup Test Observations and Summary

Step 10: Reading this section will help you make some useful observations when first running the motor.

Error Codes - If the inverter displays an error code (LED format is "Exx"), see the instructions on page 6–5 to interpret and clear the error.

Acceleration and Deceleration - The L100 inverter has programmable acceleration and deceleration values. The test procedure left these at the default value, 10 seconds. You can observe this by setting the potentiometer at about half speed before running the motor. Then press RUN, and the motor will take 5 seconds to reach a steady speed. Press the STOP key to see a 5 second deceleration to a stop.

State of Inverter at Stop - If you adjust the motor's speed to zero, the motor will slow to a near stop, and the inverter turns the outputs off. The high-performance L100 can rotate at a very slow speed with high torque output, but not zero (must use servo systems with position feedback for that feature). This characteristic means you must use a mechanical brake for some applications.

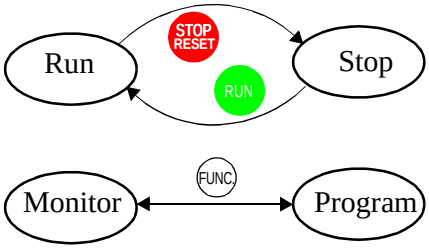
Interpreting the Display - First, let's interpret the output frequency display readout. The maximum frequency setting (parameter A4) defaults to 50Hz or 60 Hz (Europe and United States, respectively) for your application.

Example: Suppose a 4-pole motor is rated for 60 Hz operation, so the inverter is configured to output 60 Hz at full scale. Let's use the following formula to calculate the RPM.

$$\text{Speed in RPM} = \frac{Frequency \times 60}{\text{Pairs of poles}} = \frac{Frequency \times 120}{\text{\# of poles}} = \frac{60 \times 120}{4} = 1800\,\text{RPM}$$

The theoretical speed for the motor is 1800 RPM (speed of torque vector rotation). However, the motor cannot generate torque unless its shaft turns at a slightly different speed. This difference is called *slip.* So it's common to see a rated speed of approximately 1750 RPM on a 60 Hz, 4-pole motor. Using a tachometer to measure shaft speed, you can see the difference between the inverter output frequency and the actual motor speed. The slip increases slightly as the motor's load increases. This is why the inverter output value is called "frequency," since it is not exactly equal to motor speed. You can program the inverter to display output frequency in units more directly related to the load speed by entering a constant (discussed more in depth on page 3–25).

Run/Stop versus Monitor/Program modes – The Run LED on the inverter is On in the Run Mode, and Off in the Stop Mode. The Program LED is On when the inverter is in the Program Mode, and Off for Monitor Mode. All four mode combinations are possible. The diagram to the right depicts the modes and the mode transitions from keypad commands.



NOTE: Some factory automation devices such as PLCs have alternate Run/Program modes; the device is in either one mode or the other. In the Hitachi inverter, however, Run Mode alternates with Stop Mode, and Program Mode alternates with Monitor Mode. This arrangement lets you program some values while the inverter is operating — providing flexibility for maintenance personnel.

Configuring Drive Parameters

3

In This Chapter.... page

Choosing a Programming Device

Introduction

Hitachi variable frequency drives (inverters) use the latest electronics technology for getting the right AC waveform to the motor at the right time. The benefits are many, including energy savings and higher machine output or productivity. The flexibility required to handle a broad range of applications has required ever more configurable options and parameters — inverters are now a complex industrial automation component. And this can make a product seem difficult to use, but the goal of this chapter is to make this easier for you.

As the powerup test in Chapter 2 demonstrated, you do not have to program very many parameters to run the motor. In fact, most applications would benefit only from programming just a few, specific parameters. This chapter will explain the purpose of each set of parameters, and help you decide which ones are important to your application.

If you are developing a new application for the inverter and a motor, finding the right parameters to change is mostly an exercise in optimization. Therefore, it is OK to begin running the motor with a loosely tuned system. By making specific, individual changes and observing their effects, you can achieve a finely tuned system.

Introduction to Inverter Programming

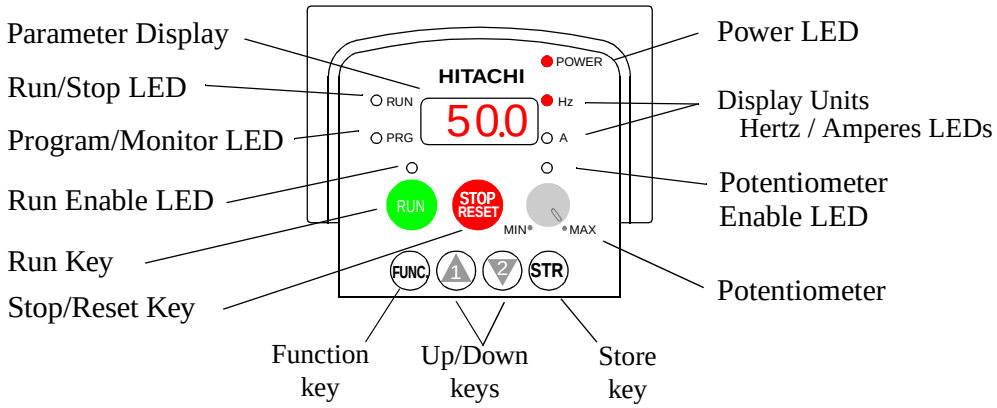
The front panel keypad is the first and best way to get to know the inverter's capabilities. Every function or programmable parameter is accessible from the keypad. The other devices simply imitate the keypad's layout and inverter access, while adding another valuable aspect to the system. In this way, you can use a variety of programming devices with basically the same keypad skills. The following table shows various programming options, the features unique to each device, and the cables required.

Device	Part Number	Parameter Access	Parameter setting storage	Cables (choose one)	
				Part number	Length
Inverter keypad	—	Monitor and program	EEPROM in inverter	—	—
DOP Plus Software (for PC)	DOP–PLUS	Monitor and program	PC hard drive or diskette	(Included with software)	2 meters
Remote Digital Operator Panel	DOP–OEA	Monitor and program	none on DOP	ICA–0.6L	0.6 meters
				ICA–1L	1 meter
				ICA–3L	3 meters
Read/Write Digital Operator Panel	DRW–OEA2	Monitor and program	EEPROM in operator panel	Use same 3 cables as above.	
Operator Monitor	OPE–J	Monitor only	none on operator monitor	ICL–0.6L	0.6 meters
				ICL–1L	1 meter

Using Keypad Devices

Inverter Font Panel Keypad

The L100 Series inverter front keypad contains all the elements for both monitoring and programming parameters. The keypad layout is pictured below. All other programming devices for the inverter have a similar key arrangement and function. The *DOP Plus* PC software has an on-screen keypad as well.

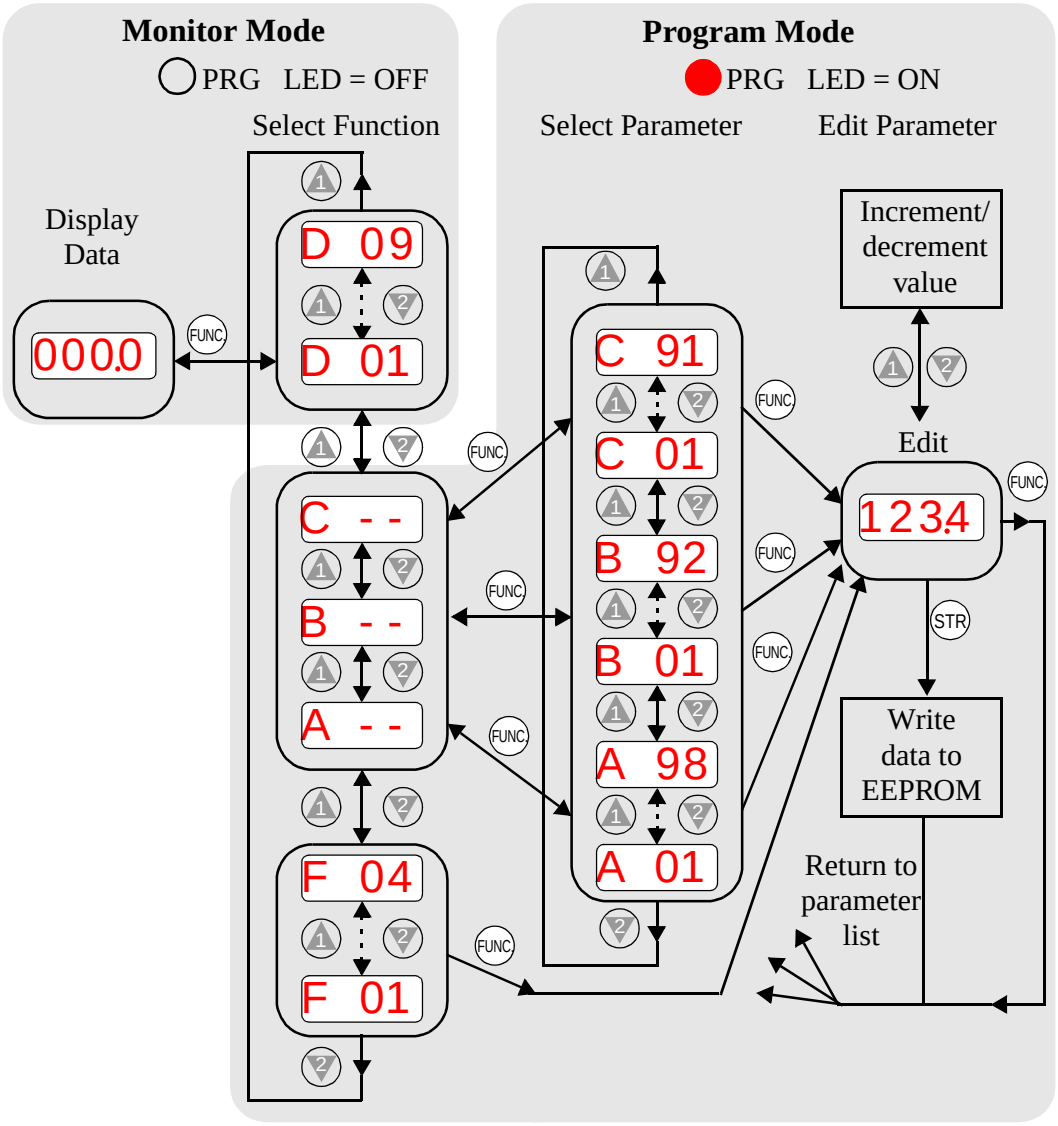


Key and Indicator Legend

- **Run/Stop LED** - On when the inverter output is running the motor (Run Mode), and Off when the inverter output is Off (Stop Mode).
- **Program/Monitor LED** - This LED is On when the inverter is ready for parameter editing (Program Mode). It is Off when the parameter display is monitoring data (Monitor Mode).
- **Run Key** - Press this key to run the motor (the Run Enable LED must be On first).
- **Run Enable LED** - is On when the inverter is ready to respond to the Run command, Off when the Run command is disabled.
- **Stop/Reset Key** - Press this key to stop the motor when it is running (uses the programmed deceleration rate). This key will also reset an alarm which has tripped.
- **Potentiometer** - allows an operator to enter data for selecting a scalar value from a range, associated with the inverter output frequency.
- **Potentiometer Enable LED** - On when the potentiometer is enabled for value entry.
- **Parameter Display** - a 4-digit, 7-segment display for parameters and function codes.
- **Display Units, Hertz/Amperes** - One of these LEDs will be On to indicate the units associated with the parameter display.
- **Power LED** - This LED is On when the power input to the inverter is On.
- **Function Key** - This key is used to navigate through the lists of parameters and functions for setting and monitoring parameter values.
- **Up/Down (▲1, ▼2) Keys** - Use these keys to alternately move up or down the lists of parameter and functions shown in the display, and increment/decrement values.
- **Store (STR) Key** - When the unit is in Program Mode and the operator has edited a parameter value, press the Store key to write the new value to the EEPROM.

Keypad Navigational Map

Whether you use the keypad on the inverter, the DOP software for the personal computer, or the hand-held digital operator panel, each navigates the same way. The diagram below shows the basic navigational map of parameters and functions.

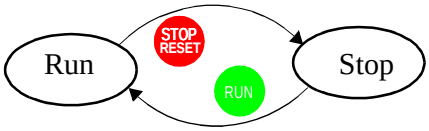


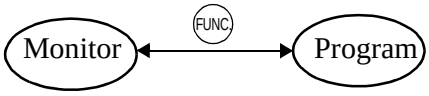
NOTE: The inverter 7-segment display shows lower case “b” and “d”, which means the same as the upper case letters “B” and “D” used in this manual (for uniformity “A to F”).

NOTE: The Store Key saves the edited parameter (shown in the display) to the EEPROM in the inverter, regardless of the programming device. Upload and download of parameters is accomplished through a separate command — do not confuse *Store* with *Download* or *Upload*.

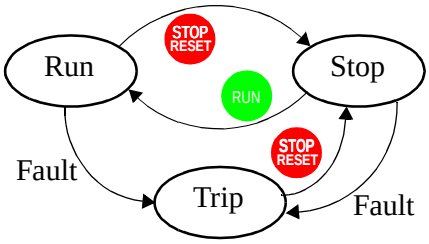
Operational Modes

The RUN and PGM LEDs tell just part of the story; Run Mode and Program Modes are independent modes, not opposite modes. In the state diagram to the right, Run alternates with Stop, and Program Mode alternates with Monitor Mode. This is a very important ability, for it shows that a technician can approach a running machine and change some parameters without shutting down the machine.



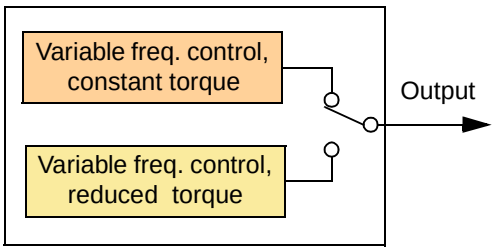


The occurrence of a fault during operation will cause the inverter to enter the Trip Mode as shown. An event such as an output overload will cause the inverter to exit the Run Mode and turn off its output to the motor. In the Trip Mode, any request to run the motor is ignored. You must clear the error by pressing the Stop/Reset switch. See page 6–5 for error codes and trip history monitoring in detail.



Inverter PWM Switching Algorithms

The motor control program in the L100 inverter has two PWM sinusoidal switching algorithms. The intent is that you select the best algorithm for the motor characteristics in your application. Both algorithms generate the frequency output in a unique way. Once configured, the algorithm is the basis for other parameter settings as well (see page 3–13). Therefore, choose the best algorithm early in your application design process.



Other Keypad Programming Devices

Several hand-held programming devices are available:

- Digital Operator Panel, DOP–0EA
- Digital Operator Panel and Read/Write Copy Unit (shown at right), DRW-0EA2
- Operator Monitor, OPE-J

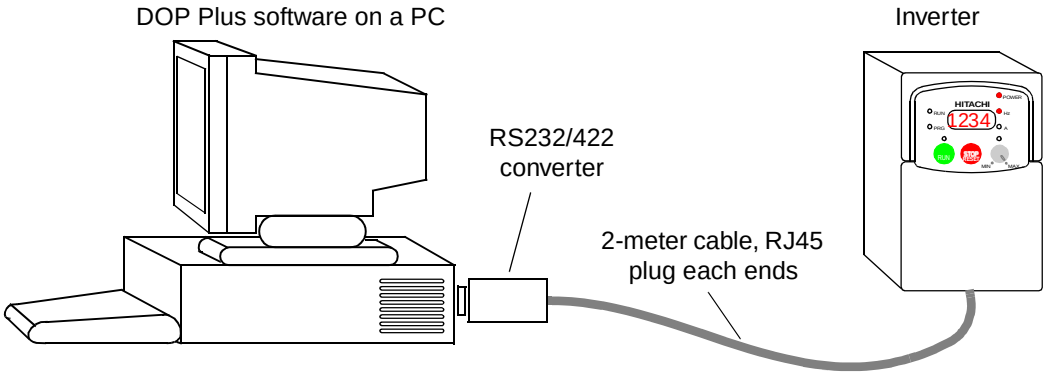
The keypads on these operator units are similar to the inverter keypad (refer to the manual that comes with each unit). These can also be panel-mounted to provide a permanent low-cost operator interface, while keeping the inverter secure within the cabinet. The LCD display on the DOP units provides more detailed parameter names and values. The DRW-0EA2 Copy Unit lets you read the parameters from one unit and copy them to another. The Operator Monitor can view (but not edit) parameters. See Appendix B for DOP monitor and function tables. Contact your local Hitachi distributor for more product information.

Using the PC Software — DOP Plus

During application development, using the DOP Plus software is a great way to configure your inverter. This package works with several Hitachi inverter families, providing these features:

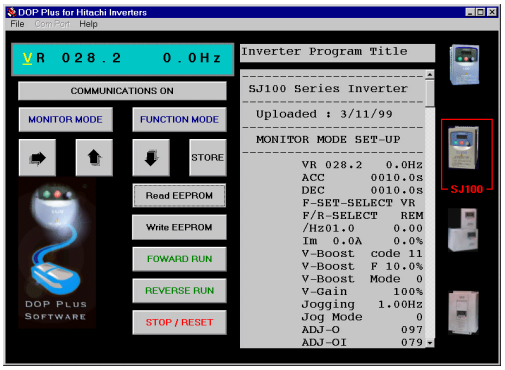
- Automatic detection of inverter family
- Save parameter settings to disk
- Load parameters settings from disk
- Print all parameters and functions
- Compare inverter settings with disk file
- RS232/422 converter and cable included
- Built-in help screens for functions
- Automatic Quick Function Parameter Select
- Runs on a PC with either Windows 3.1, Win95/98, or Windows NT

Initial setup is easy, using the 2-meter cable and RS232/422 converter as shown below. The RS422 electrical characteristics are more noise-immune to electrical interference from inverters and large motors. We recommend that you keep the communications cable away from inverter power supply or motor wiring as a precaution.



When you connect the cable and go on-line with the DOP software, the inverter keypad is disabled (except for the Stop/Reset key). When you go off-line or disconnect the cable, the inverter keypad becomes fully enabled.

Programming with the DOP Plus



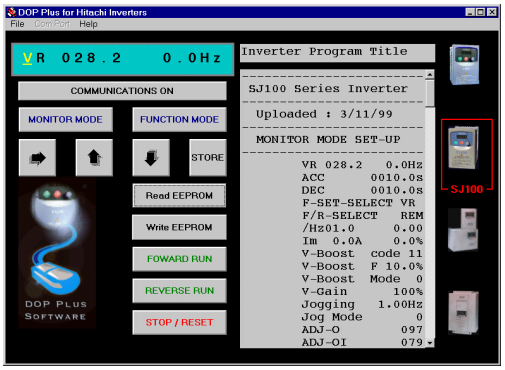
The screen arrangement is similar to the inverter keypad. Additional buttons *Read EEPROM* and *Write EEPROM* let you upload or download parameter settings. After doing a *Read EEPROM*, all the inverter's parameter settings will be accessible in the scrollable list box. Just double-click any parameter to begin editing.

It is important to understand that the way you reference parameters with the DOP Plus is different from the inverter keypad and display. The inverter must use a simple code to identify a parameter, while all the remote terminals and the DOP Plus software have multiple-character capability. Therefore, the software uses more complete parameter names and a different numbering system to index (reference) the parameters. The tables in this chapter list the parameters in the sequence of the inverter keypad, with a cross-reference to the Digital Operator Panels and DOP Plus software parameter names in the right-most column. The diagram below shows a table from this chapter and the DOP+ parameter name cross-references.

DOP function code and name

Parameter tables in this manual

"A" Function			Run-time Edit	Defaults		DOP,DRW,DOP+	
Func. Code	Name	Description		EU/ US	Units	Func. Code	Name
A61	Frequency upper limit setting	Sets a limit on output frequency less than the maximum frequency (A04) Range is 0.5 to 360.0 Hz 0.0...setting is disabled >0.1 setting is enabled	✘	0.0	Hz	F-26	LIMIT H
A62	Frequency lower limit setting	Sets a limit on output frequency greater than zero Range is 0.5 to 360.0 Hz 0.0...setting is disabled >0.1 setting is enabled	✘	0.0	Hz	F-26	LIMIT L
A63, A65, A67	Jump (center) frequency setting	Up to 3 output frequencies can be defined for the output to jump past to avoid motor resonances (center frequency) Range is 0.0 to 360.0 Hz	✘	0.0 0.0 0.0	Hz	F-27	JUMP F1 JUMP F2 JUMP F3
A64, A66, A68	Jump (hysteresis) frequency width setting	Defines the distance from the center frequency at which the jump around occurs Range is 0.0 to 10.0 Hz	✘	0.5 0.5 0.5	Hz	F-27	JUMP W1 JUMP W2 JUMP W3



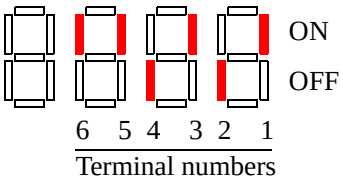
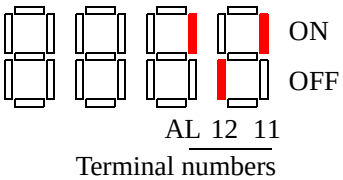
TIP: We recommend choosing a particular programming tool at the beginning of your inverter configuration project. Avoid switching programming tools until you become familiar with most or all of the inverter parameters.

The DOP Plus software comes with an instruction manual. Please refer to that manual for details on how to establish communications with the inverter from your PC, and how to edit, upload, and download parameters. See Appendix B for DOP monitor and function tables.

“D” Group: Monitoring Functions

Parameter Monitoring Functions

You can access important system parameter values with the “D” group monitoring functions, whether the inverter is in Run Mode or Stop Mode. After selecting the function code number for the parameter you want to monitor, press the Function key once to show the value on the display. In Functions D05 and D06, the intelligent terminals use individual segments of the display to show On/Off status.

“D” Function			Run-time Edit	Range and Units	DOP,DRW,DOP+	
Func. Code	Name	Description			Func. Code	Name
D01	Output frequency monitor	Real-time display of output frequency to motor, from 0.0 to 360.0 Hz	—	0.0 to 360.0 Hz	Monitor: FS, 2FS, TM, VR, 1 to 15 S	
D02	Output current monitor	Filtered display of output current to motor (100 mS internal filter time constant)	—	A	Mon.	Im
D03	Rotation direction monitor	Three different indications: “F”..... Forward “| |” .. Stop “r”..... Reverse	—	—	Mon.	VR
D04	Process variable (PV), PID feedback monitor	Displays the scaled PID process variable (feedback) value (A75 is scale factor)	—	—	Monitor: FSP, 2FP, TMP, VRP, 1 to 15S	
D05	Intelligent input terminal status	Displays the state of the intelligent input terminals:  	—	—	Mon.	TERM
D06	Intelligent output terminal status	Displays the state of the intelligent output terminals:  	—	—	Mon.	TERM
D07	Scaled output frequency monitor	Displays the output frequency scaled by the constant in B86. Decimal point indicates range: XX.XX 0.01 to 99.99 XXX.X 100.0 to 999.9 XXXX. 1000 to 9999 XXXX 10000 to 99990	—	Hz	Mon.	/Hz

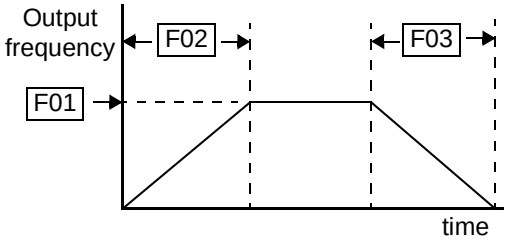
Trip Event and History Monitoring

The trip event and history monitoring feature lets you cycle through related information using the keypad. More details about trip event monitoring are on page 6–5.

"D" Function			Run-time Edit	Range and Units	DOP,DRW,DOP+	
Func. Code	Name	Description			Func. Code	Name
D08	Trip event monitor	Displays the current trip event. information.	—	—	Mon.	ERR1
D09	Trip history monitor	Displays the previous two events and their causes.	—	—	Mon.	ERROR COUNT, ERR2, ERR3

"F" Group: Main Profile Parameters

The basic frequency (speed) profile is defined by parameters contained in the "F" group as shown to the right. The set running frequency is in Hz, but acceleration and deceleration are specified in the time duration of the ramp (from zero to maximum frequency, or from maximum frequency to zero). The motor direction parameter determines whether the keypad Run key produces a FWD or REV command. This parameter does not affect the intelligent terminal FWD and REV functions, which are already separate.



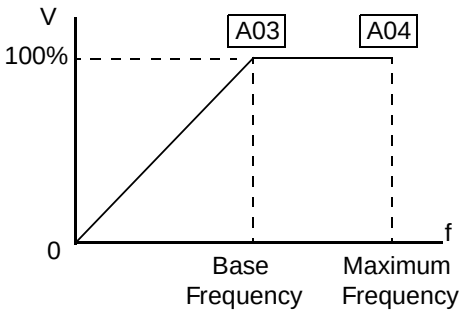
"F" Function			Run-time Edit	Range and Units	DOP,DRW,DOP+	
Func. Code	Name	Description			Func. Code	Name
F01	Output frequency setting	Standard default target frequency that determines constant motor speed	✔	0 to 360 Hz	Mon.	FS, 2FS, TH, VR, 1 to 15S
F02	Acceleration 1	Standard default acceleration	✔	0.1 to 3000 sec.	Mon.	ACC1
F03	Deceleration 1	Standard default deceleration	✔	0.1 to 3000 sec.	Mon.	DEC1
F04	Motor direction	Two options; select codes: 00 .. Forward 01 .. Reverse	✘	00, 01	Mon.	F/R-Select

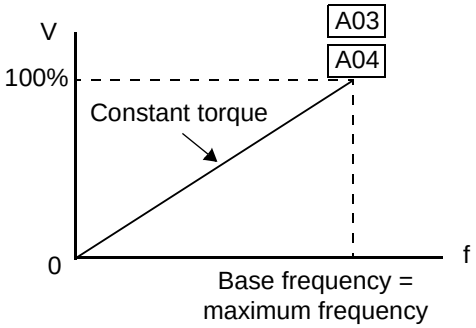
"A" Group: Standard Functions

Basic Parameter Settings

These settings affect the most fundamental behavior of the inverter — the outputs to the motor. The frequency of the inverter's AC output determines the motor speed. You may select from three different sources for the reference speed. During application development you may prefer using the potentiometer, but you may switch to an external source (control terminal setting) in the finished application, for example.

The base frequency and maximum frequency settings interact according to the graph below (left). The inverter output operation follows the constant V/F curve until it reaches the full-scale output voltage. This initial straight line is the constant-torque part of the operating characteristic. The horizontal line over to the maximum frequency serves to let the motor run faster, but at a reduced torque. If you want the motor to output constant torque over its entire operating range (limited to the motor nameplate voltage and frequency rating), then set the base frequency and maximum frequency equal as shown (below right).



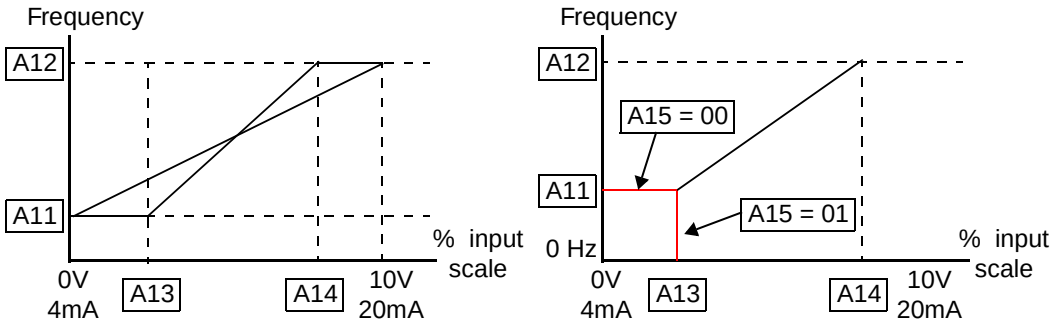


"A" Function			Run-time Edit	Defaults		DOP,DRW,DOP+	
Func. Code	Name	Description		EU/ US	Units	Func. Code	Name
A01	Frequency source setting	Three options; select codes: 00...Keypad potentiometer 01...Control terminal 02...Function F01 setting	✘	01	—	Mon.	F-SET-SELECT
A02	Run command source setting	Two options; select codes: 01...Control terminal 02...Run key on keypad, or digital operator	✘	01	—	Mon.	F/R-SELECT
A03	Base frequency setting	Settable from 50 Hz to the maximum frequency	✘	50/60	Hz	F-00	F-BASE
A04	Maximum frequency setting	Settable from the base frequency up to 360 Hz	✘	50/60	Hz	F-01	F-MAX

Analog Input Settings

The inverter has the capability to accept an external analog input that can command the output frequency to the motor. Voltage input (0 –10V) and current input (4–20mA) are available on separate terminals ("O" and "OI," respectively). The analog input settings add scaling and offset adjustments between the analog input and the frequency output.

In the graph below (left), A13 and A14 select the active portion of the input voltage or current range. The parameters A11 and A12 select the start and end frequency of the converted output frequency range, respectively. Together, these four parameters define a line segment as shown (below, right). When the line does not begin at the origin, A15 defines whether the inverter outputs 0Hz or the A11frequency when the analog input value is less than the A13 setting (determines the non-linear part of the translation).



"A" Function			Run-time Edit	Defaults		DOP,DRW,DOP+	
Func. Code	**Name**	**Description**		**EU/ US**	**Units**	**Func. Code**	**Name**
A11	External frequency output zero reference	The output frequency corresponding to the analog input range starting point	✘	0	**Hz**	F-31	IN EXS
A12	External frequency output span reference	The output frequency corresponding to the analog input range ending point	✘	0	**Hz**	F-31	IN EXE
A13	External frequency input bias start	The starting point (offset) for the active analog input range	✘	0	**%**	F-31	IN EX%S
A14	External frequency input bias end	The ending point (offset) for the active analog input range	✘	100	**%**	F-31	IN EX%E
A15	External frequency offset enable	Two options; select codes: 00...Use offset (A11 value) 01...Use 0 Hz	✘	01	—	F-31	IN LEVEL
A16	External frequency filter time constant	Range n = 1 to 8, where n = number of samples for avg.	✘	8	Samples	F-31	IN F-SAMP

Multi-speed Frequency Setting

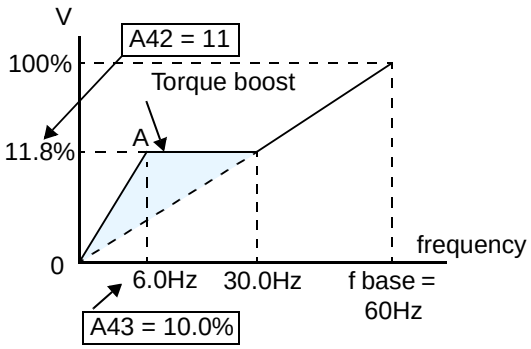
The L100 inverter has the capability to store and output up to 16 frequencies to the motor (A20 to A35). As in traditional motion terminology, we call this *multi-speed profile* capability. Binary-encoded logic inputs select the particular frequency (speed) setting, and the inverter applies the current acceleration or deceleration setting required to change from the current output frequency to the new one.

The jog speed setting is used whenever the Jog command is active. The jog speed setting range is arbitrarily limited to 10 Hz, to provide safety during manual operation. The acceleration to the jog frequency is instantaneous, but you can choose from three modes for the best method for stopping the jog operation.

"A" Function			Run-time Edit	Defaults		DOP,DRW,DOP+	
Func. Code	**Name**	**Description**		**EU/ US**	**Units**	**Func. Code**	**Name**
A20	Multi-speed frequency setting	Defines the first speed of a multi-speed profile, range is 0 to 360 Hz	✔	0	Hz	F-11	SPD FS
A21 to A35	Multi-speed frequency settings	Defines 15 more speeds, range is 0 to 360 Hz. A21 = Speed 2... A35 = Speed 16	✔	0 (all)	Hz	F-11	SPD 1 to SPD 15
A38	Jog frequency setting	Defines limited speed for jog, range is 0.5 to 9.99 Hz	✔	1.0	Hz	Mon.	JOGGING
A39	Jog stop mode	Define how end of jog stops the motor; three options: 00...Free-run stop 01...Controlled deceleration 02...DC braking to stop	✘	00	—	Mon.	JOG MODE

V/F Characteristics

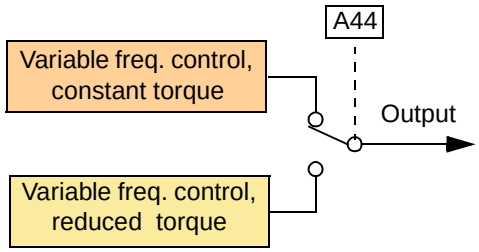
When the motor load has a lot of inertia or starting friction, you may need to increase the low frequency starting torque characteristics by boosting the voltage above the normal V/F ratio (shown at right). The boost is applied from zero to 1/2 the base frequency. You set the breakpoint of the boost (point A on the graph) by using parameter A43. The manual boost is calculated as an addition to the standard straight V/F line (constant torque curve).

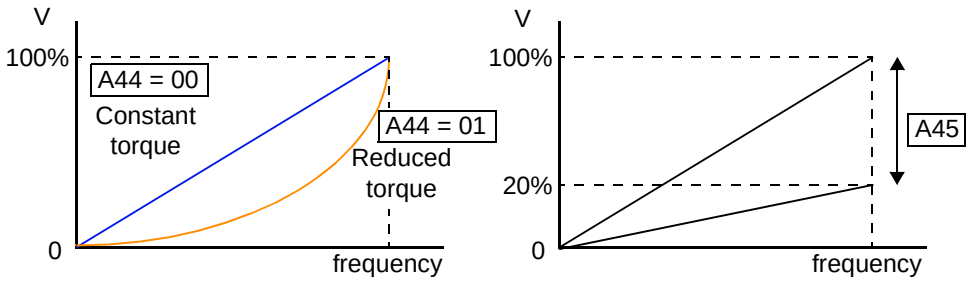


Be aware that running the motor at a low speed for a long time can cause motor overheating. This is particularly true when manual torque boost is on, or if the motor relies on a built-in fan for cooling.

Parameter A44 selects the inverter algorithm for generating the frequency output, as shown in the diagram to the right. The inverter generates the motor output according to the V/F algorithm selected. The V/F curve is oriented toward developing constant torque or reduced torque (see graph below, left). You can select either constant torque or reduced torque V/F control.

Inverter PWM Switching Algorithms





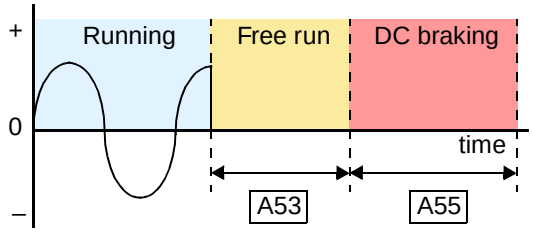
Using parameter A45 you can modify the voltage gain of the inverter (see graph above, right). This is specified as a percentage of the full scale setting (Automatic Voltage Regulation) AVR level in parameter-F03. The gain can be set from 20% to 100%. It should be adjusted in accordance with the motor specifications.

The following table shows the methods of torque control selection.

"A" Function			Run-time Edit	Defaults		DOP,DRW,DOP+	
Func. Code	Name	Description		EU/ US	Units	Func. Code	Name
A41	Torque boost method selection	Two options: 00...Manual torque boost 01...Automatic torque boost	✘	00	—	F-50	V-BOOST MODE
A42	Manual torque boost value	Can boost starting torque between 0 and 99% above normal V/F curve, from 0 to 1/2 base frequency	✔	11	—	F-50	V-BOOST CODE
A43	Manual torque boost frequency adjustment	Sets the frequency of the V/F breakpoint A in graph (top of previous page) for torque boost	✔	10	%	F-50	V-BOOST F
A44	V/F characteristic curve selection	Two available V/F curves; three select codes: 00...Constant torque 01...Reduced torque	✘	0	—	F-04	Control
A45	V/F gain setting	Sets voltage gain of the inverter from 20 to 100%	✔	100	%	Mon.	V-GAIN

DC Braking Settings

The DC braking feature provides additional stopping power when compared to just a normal deceleration to a stop. DC braking is particularly useful at the low frequency end of the deceleration ramp where there is little or no motor torque available for stopping. If you enable DC braking, it turns on during deceleration at a frequency you can specify. If desirable, you can specify a delay time during which the motor coasts (free runs) before DC braking helps stop the rotation.

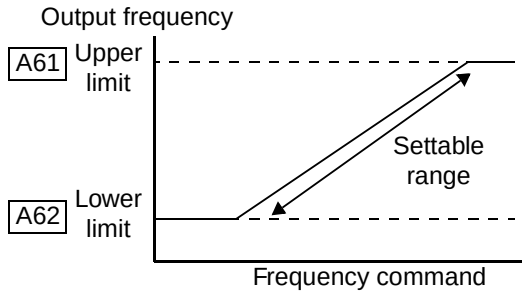


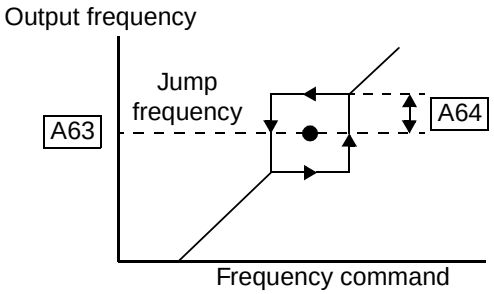
Most importantly, the force and duration of DC braking are adjustable. Be careful to not specify a long braking time that causes motor overheating. If you use DC braking, we recommend using a motor with a built-in thermistor, and wiring it to the inverter's thermistor input (see page 4–17). Also refer to the motor manufacturer's specifications for duty-cycle recommendations during DC braking.

"A" Function			Run-time Edit	Defaults		DOP,DRW,DOP+	
Func. Code	**Name**	**Description**		**EU/ US**	**Units**	**Func. Code**	**Name**
A51	DC braking enable	Two options; select codes: 00...Disable 01...Enable	✘	00	—	F-20	DCB SW
A52	DC braking frequency setting	The frequency at which DC braking occurs, range is 0.5 to 10 Hz	✘	0.5	Hz	F-20	DCB F
A53	DC braking wait time	The delay from the end of Run command to start of DC braking (motor free runs until DC braking begins)	✘	0.0	sec.	F-20	DCB WAIT
A54	DC braking force setting	Applied level of DC braking force, settable from 0 to 100%	✘	0	%	F-20	DCB V
A55	DC braking time setting	Sets the duration for DC braking, range is 0.1 to 60.0 seconds	✘	0.0	sec.	F-20	DCB T

Frequency-related Functions

The inverter output generates a variable-frequency waveform that determines the motor speed (minus slip losses). You can configure the lower frequency limit to be greater than zero as shown in the graph (below left). The upper limit must not exceed the rating of the motor or capability of the machinery. Some motors or machines exhibit resonances at a particular speed, which can be destructive. The inverter has up to three *jump frequencies* (see graph, below right) with hysteresis around them to cause the inverter output to skip around the sensitive frequency values.





"A" Function			Run-time Edit	Defaults		DOP,DRW,DOP+	
Func. Code	Name	Description		EU/ US	Units	Func. Code	Name
A61	Frequency upper limit setting	Sets a limit on output frequency less than the maximum frequency (A04) Range is 0.5 to 360.0 Hz 0.0..setting is disabled >0.1 setting is enabled	✘	0.0	Hz	F-26	LIMIT H
A62	Frequency lower limit setting	Sets a limit on output frequency greater than zero Range is 0.5 to 360.0 Hz 0.0..setting is disabled >0.1 setting is enabled	✘	0.0	Hz	F-26	LIMIT L
A63, A65, A67	Jump (center) frequency setting	Up to 3 output frequencies can be defined for the output to jump past to avoid motor resonances (center frequency) Range is 0.0 to 360.0 Hz	✘	0.0 0.0 0.0	Hz	F-27	JUMP F1 JUMP F2 JUMP F3
A64, A66, A68	Jump (hysteresis) frequency width setting	Defines the distance from the center frequency at which the jump around occurs Range is 0.0 to 10.0 Hz	✘	0.5 0.5 0.5	Hz	F-27	JUMP W1 JUMP W2 JUMP W3

PID Control

When enabled, the built-in PID loop calculates an ideal inverter output value to cause a loop feedback process variable (PV) to move closer in value to the setpoint (SP). The current frequency command serves as the SP. The PID loop calculations will read the analog input for the process variable (you specify the current or voltage input) and calculate the output. A scale factor in A75 lets you multiply the PV by a factor, converting it into engineering units for the process. Proportional, integral, and derivative gains are all adjustable. See page 4–27 for more information on PID loop control.

"A" Function			Run-time Edit	Defaults		DOP,DRW,DOP+	
Func. Code	Name	Description		EU/ US	Units	Func. Code	Name
A71	PID Function Enable	Enables PID function, two option codes: 00...PID Disable 01...PID Enable	✘	00	—	F-43	PID SW
A72	PID proportional gain	Proportional gain has a range of 0.2 to 5.0	✘	1.0	—	F-43	PID P
A73	PID integral time constant	Integral time constant has a range of 0.0 to 150 seconds	✘	1.0	sec.	F-43	PID I
A74	PID derivative gain	Derivative gain has a range of 0.0 to 100 seconds	✘	0.0	sec.	F-43	PID D
A75	PV scale conversion	Process Variable (PV) scale factor (multiplier), range of 0.01 to 99.99	✘	1.0	—	F-43	PID CONV
A76	PV source setting	Selects source of Process Variable (PV), option codes: 00..."OI" terminal (current in) 01..."O" terminal (voltage in)	✘	00	—	F-43	PID INPT

NOTE: The setting A73 for the integrator is the integrator's time constant Ti, not the gain. The integrator gain Ki = 1/Ti. When you set A73 = 0, the integrator is disabled.

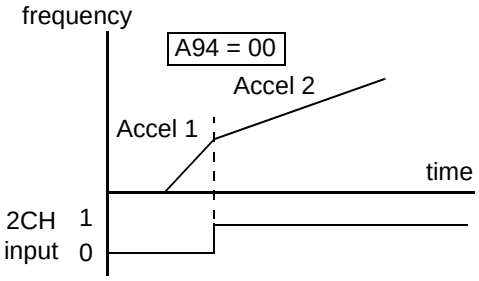
Automatic Voltage Regulation (AVR) Function

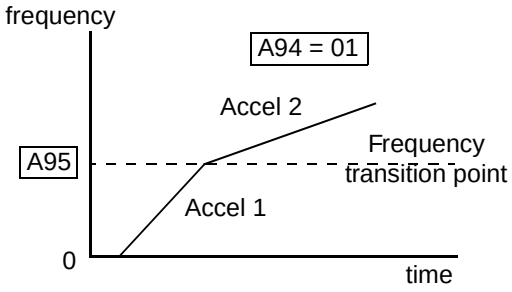
The automatic voltage regulation (AVR) feature keeps the inverter output waveform at a relatively constant amplitude during power input fluctuations. This can be useful if the installation has an erratic power source. However, the inverter cannot boost its motor output to a voltage higher than the power input voltage. If you enable this feature, be sure to select the proper voltage class setting for your motor.

"A" Function			Run-time Edit	Defaults		DOP,DRW,DOP+	
Func. Code	Name	Description		EU/ US	Units	Func. Code	Name
A81	AVR function select	Automatic (output) voltage regulation, selects from three type of AVR functions, three option codes: 00...AVR enabled 01...AVR disabled 02...AVR enabled except during deceleration	✘	02	—	F-03	AVR MODE
A82	AVR voltage select	200V class inverter settings: .....200/220/230/240 400V class inverter settings: 380/400/415/440/460	✘	230/ 230, 400/ 460	V	F-03	AVR AC

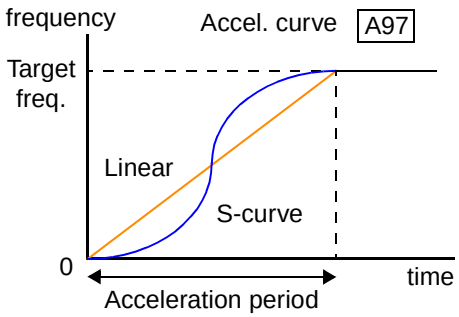
Second Acceleration and Deceleration Functions

The L100 inverter features two-stage acceleration and deceleration ramps. This gives flexibility in the profile shape, and can avoid jerk (mechanical shock) while approaching steady frequency (or stop) more gently. You can specify the frequency transition point, the point at which the standard acceleration (F02) or deceleration (F03) changes to the second acceleration (A92) or deceleration (A93). Select a transition frequency method via A94 as depicted below.





Standard acceleration and deceleration is linear. The inverter CPU can also calculate an S-curve acceleration and deceleration curve as shown. This profile avoids abrupt changes in velocity, to reduce shock to the motor load. The CPU fits the S-curve acceleration or deceleration to a time period you specify. It is also possible to have a linear acceleration and an S-curve deceleration, for example.



To enable the S-curve, use function A97 (acceleration) and A98 (deceleration).

"A" Function			Run-time Edit	Defaults		DOP,DRW,DOP+	
Func. Code	Name	Description		EU/ US	Units	Func. Code	Name
A92	Second acceleration time setting	Duration of 2nd segment of acceleration, range is: 0.1 to 3000 sec.	✔	15.0	sec.	F-06	ACC2
A93	Second deceleration time setting	Duration of 2nd segment of deceleration, range is: 0.1 to 3000 sec.	✔	15.0	sec.	F-07	DEC 2
A94	Select method to use second accel/decel	Two options for switching from 1st to 2nd accel/decel: 00...2CH input from terminal 01...transition frequency	✘	00	—	F-06	ACC CHG
A95	Acc1 to Acc2 frequency transition point	Output frequency at which Accel1 switches to Accel2, range is 0.0 to 360.0 Hz	✘	0.0	Hz	F-06	ACC CHFr

"A" Function			Run-time Edit	Defaults		DOP,DRW,DOP+	
Func. Code	Name	Description		EU/ US	Units	Func. Code	Name
A96	Dec1 to Dec2 frequency transition point	Output frequency at which Decel1 switches to Decel2, range is 0.0 to 360.0 Hz	✘	0.0	Hz	F-07	DEC CHFr
A97	Acceleration curve selection	Set the characteristic curve of Acc1 and Acc2, two options: 00...linear 01...S-curve	✘	00	—	F-06	ACC LINE
A98	Deceleration curve setting	Set the characteristic curve of Acc1 and Acc2, two options: 00...linear 01...S-curve	✘	00	—	F-07	DEC LINE

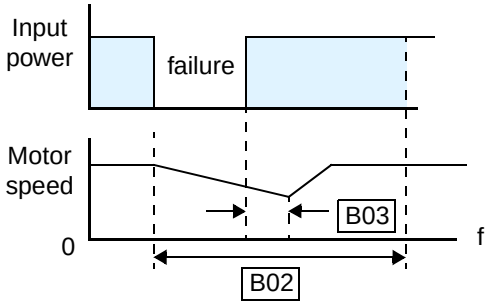
NOTE: For A95 and A96, if you set a very rapid Acc1 or Dec1 time (less than 1.0 second), the inverter may not be able to change rates to Acc2 or Dec2 before reaching the target frequency. In that case, the inverter decreases the rate of Acc1 or Dec1 in order to achieve the second ramp to the target frequency.

"B" Group: Fine Tuning Functions

The "B" group of functions and parameters adjust some of the more subtle but useful aspects of motor control and system configuration.

Restart Mode

The restart mode determines how the inverter will resume operation after a fault causes a trip event. The four options provide advantages for various situations. The inverter can restart several times for particular trip events:



- Over-current trip, restart up to 3 times
- Over-voltage trip, restart up to 3 times
- Under-voltage trip, restart up to 16 times

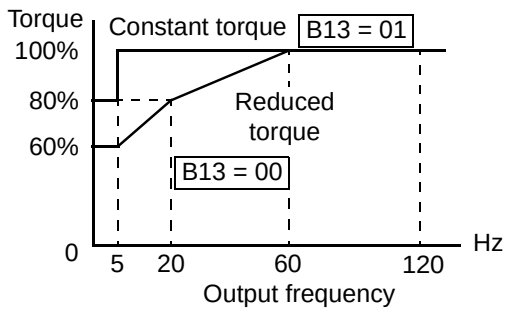
When the inverter reaches the maximum number of restarts (3 or 16), you must power-cycle the inverter to reset its operation.

Other parameters specify the allowable under-voltage level and the delay time before restarting. The proper settings depends on the typical fault conditions for your application, the necessity of restarting the process in unattended situations, and whether restarting is always safe.

"B" Function			Run-time Edit	Defaults		DOP,DRW,DOP+	
Func. Code	Name	Description		EU/ US	Units	Func. Code	Name
B01	Selection of restart mode	Select inverter restart method, four option codes: 00...Alarm output after trip, no automatic restart 01...Restart at 0Hz 02...Resume operation after frequency matching 03...Resume previous freq. after freq. matching, then decelerate to stop and display trip info.	✘	00	—	F-22	IPS POWR
B02	Allowable under-voltage power failure time	The amount of time a power input under-voltage can occur without tripping the power failure alarm. Range is 0.3 to 25 sec. If under-voltage exists longer than this time, the inverter trips, even if the restart mode is selected.	✘	1.0	sec.	F-22	IPS UVTIME
B03	Time delay enforced before motor restart	Time delay after under-voltage condition goes away, before the inverter runs motor again. Range is 0.3 to 100 seconds.	✘	1.0	sec.	F-22	IPS WAIT

Electronic Thermal Overload Alarm Setting

The thermal overload detection protects the inverter and motor from excessive heat. First use B13 to select the torque characteristic as a function of frequency. For example, a motor can overheat if it runs for too long at a low speed. You can counteract this effect by reducing the torque at low speed. Otherwise, use the constant torque characteristic.



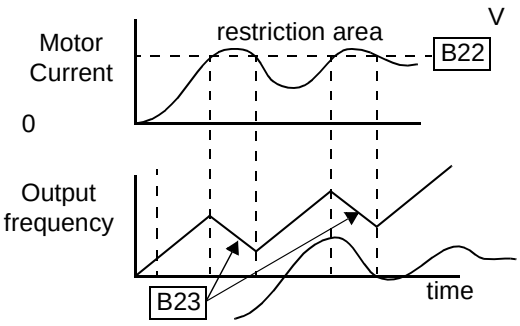
The torque developed in a motor is directly proportional to the current in the windings, which is also proportional to the heat generated (and temperature, over time). Therefore, you must set the thermal overload threshold in terms of current (amperes) for parameter B12. The range is 50% to 120% of the rated current for each model of inverter. If the current exceeds the level you specify, the inverter will trip and log an event (error E5) in the history table. The inverter turns the motor output off when tripped.

"B" Function			Run-time Edit	Defaults		DOP,DRW,DOP+	
Func. Code	Name	Description		EU/ US	Units	Func. Code	Name
B12	Level of electronic thermal setting	Set a level between 50% and 120% for the rated inverter current.	✘	rated Amps *Note	%	F-23	E-THM LVL
B13	Electronic thermal characteristic	Select from two curves, option codes: 00...(SUB) reduced torque 01...(CRT) constant torque	✘	01	A	F-23	E-THM Char Sub

NOTE: For inverter models 005NFE, 011NFE, and 030HFE, the thermal value is less than the rated amperes (is the same as models 004NFE, 007NFE, and 040HFE respectively). Therefore, be sure to set the electronic thermal overload according to the actual motor driven by the particular inverter.

Overload Restriction

When the inverter output current exceeds a preset current level you specify, the overload restriction feature arbitrarily reduces the output current. This feature does not generate an alarm or trip event. You can instruct the inverter to apply overload restriction only during constant speed, thus allowing higher currents for acceleration. Or, you may use the same threshold for both acceleration and constant speed.



When the inverter detects an overload, it must decelerate the motor to reduce the current until it is less than the threshold. You can choose the rate of deceleration that the inverter uses to lower the output current.

"B" Function			Run-time Edit	Defaults		DOP,DRW,DOP+	
Func. Code	Name	Description		EU/ US	Units	Func. Code	Name
B21	Overload restriction operation mode	Select the operating mode during overload conditions, three options, option codes: 00...Disabled 01...Enabled for acceleration and constant speed 02...Enabled for constant speed only	✘	01	—	F24	OLOAD MODE
B22	Overload restriction setting	Sets the level for overload restriction, between 50% and 150% of the rated current of the inverter, setting resolution is 1% of rated current	✘	rated Amps *1.25 See *Note	A	F24	OLOAD LVL
B23	Deceleration rate at overload restriction	Sets the deceleration rate when inverter detects overload, range is 0.1 to 30.0, resolution is 0.1.	✘	1.0	—	F24	OLOAD CONST

NOTE: For inverter models 005NFE, 011NFE, and 030HFE, the thermal value is less than the rated amperes (is the same as models 004NFE, 007NFE, and 040HFE respectively). Therefore, be sure to set the electronic thermal overload according to the actual motor driven by the particular inverter.

Software Lock Mode

The software lock function keeps personnel from accidentally changing parameters in the inverter memory. The feature has some options, but the software lock function (B21) is not protected from operator editing. You can lock all other parameters except the output frequency (F01), if desired. This allows the user to vary only the output frequency.

NOTE: Since the software lock function B31 is always accessible, this feature is not the same as password protection used in other industrial control devices.

"B" Function			Run-time Edit	Defaults		DOP,DRW,DOP+	
Func. Code	Name	Description		EU/ US	Units	Func. Code	Name
B31	Software lock mode selection	Prevents parameter changes, in four options, option codes: 00...all parameters except B31 are locked when SFT from terminal is on 01...all parameters except B31 and output frequency F01 when SFT from terminal is on 02...all parameters except B31 are locked 03...all parameters except B31 and output frequency F01 setting are locked	✘	01	—	F25	S-LOCK

NOTE: If redundant data protection is necessary, use one of the intelligent input terminals (1 to 5) to allow a data change only when SFT is Off.

Miscellaneous Settings

The miscellaneous settings include scaling factors, initialization modes, and others. Here we will cover some of the most important settings you may need to configure.

B32: Reactive current setting – the inverter's D02 monitor function displays the motor current. The display accuracy (normally ±20%, depending on the connected motor's characteristics) can be improved by adjustment of the B32 parameter. Use B32 to calibrate the internal no-load or reactive motor current detection to improve the accuracy of the D02 current display.

NOTE: Parameter setting B32 affects the inverter's electronical thermal protection (B12 setting) and its overload restriction function (B22 setting).

B83: Carrier frequency adjustment – the internal *switching frequency* of the inverter circuitry (also called the *chopper frequency*). It is called the carrier frequency because the lower AC output frequency of the inverter "rides" the carrier. The faint, high-pitched sound you hear when the inverter is in Run Mode is characteristic of switching power supplies in general. The carrier frequency is adjustable from 500 Hz to 16 kHz. The audible sound decreases at the higher frequencies. For settings above 12 kHz, you must derate the inverter output current by 20% (due to increased heating).

NOTE: When DC braking is performed, the inverter automatically holds the carrier frequency at 1 kHz.

NOTE: The carrier frequency setting must stay within specified limits for inverter-motor applications that must comply with particular regulatory agencies. For example, a European CE-approved application requires the inverter carrier to be less than 5 kHz.

B84, B85 – Initialization codes – these functions allow you to restore the factory default settings. Please refer to page 6–8 for full instructions on restoring factory defaults.

B86 – Frequency display scaling – you can convert the output frequency monitor on D01 to a scaled number monitored at function D07. For example, the motor may run a conveyor that is monitored in feet per minute. Use this formula:

$$\text{Scaled output frequency (D07)} = \text{Output frequency (D01)} \times \text{Factor (B86)}$$

"B" Function			Run-time Edit	Defaults		DOP,DRW,DOP+	
Func. Code	Name	Description		EU/ US	Units	Func. Code	Name
B32	Reactive current setting	Calibrate detection of motor's no load (reactive current) to improve D02 display accuracy, range is 0 to 32 Amperes	✔	58% rated current	Amps	Mon.	IO
B81	Analog frequency meter adjustment	Adjust 8-bit gain to analog meter connected to terminal FM, range is 0 to 255	✔	80	—	Mon.	ADJ

"B" Function			Run-time Edit	Defaults		DOP,DRW,DOP+	
Func. Code	Name	Description		EU/ US	Units	Func. Code	Name
B82	Start frequency adjustment	Sets the starting frequency for the inverter output, range is 0.5 to 9.9 Hz	✘	0.5	Hz	F-02	FMIN.
B83	Carrier frequency setting	Sets the PWM carrier (internal switching frequency), range is 0.5 to 16.0 kHz	✘	5	kHz	F-36	CARRIER
B84	Initialization mode (parameters or trip history)	Select the type of initialization to occur, two option codes: 00...Trip history clear 01...Parameter initialization	✘	00	—	F-38	INIT MODE
B85	Country code for initialization	Select default parameter values for country on initialization, four options, option codes: 00...Japan version 01...Europe version 02...US version 03...reserved (do not set)	✘	01/02	—	F-38	INIT SEL
B86	Frequency scalar conversion factor	Specify a constant to scale the displayed frequency for D07 monitor, range is 0.1 to 99.9	✘	1.0	—	Mon.	/HZ
B87	STOP key enable	Select whether the STOP key on the keypad is enabled, two option codes: 00...enabled 01...disabled	✘	00	—	F-28	STOP-SW
B88	Resume on FRS cancellation mode	Selects how the inverter resumes operation when the free-run stop (FRS) is cancelled, two options: 00...Restart from 0Hz 01...Restart from frequency detected from real speed of motor	✘	00	—	F-10	RUN FRS
B89	Data select for digital operator OPE-J	Select the monitoring data to send to the hand-held digital operator, seven option codes: 01...Output frequency (D01) 02...Output current (D02) 03...Motor direction (D03) 04...PID PV feedback (D04) 05...Input states for input terminals (D05) 06...Output states for output terminals (D06) 07...Scaled output frequency (D07)	✔	01	—	Mon.	PANEL

“C” Group: Intelligent Terminal Functions

The five input terminals **1**, **2**, **3**, **4**, and **5** can be configured for any of fifteen different functions. The next two tables show how to configure the five terminals. The inputs are logical, in that they are either OFF or ON. We define these states as OFF=0, and ON=1.

The inverter comes with default options for the five terminals. These default settings are initially unique, each one having its own setting. Note that European and US versions have different default settings. You can use any option on any terminal, and even use the same option twice to create a logical OR (though usually not required).

NOTE: Terminal **5** has the ability to be a logical input, and to be an analog input for a thermistor device when the PTC function (option code 19) is assigned to that terminal.

Input Terminal Configuration

Functions and Options –The *function codes* in the following table let you assign one of fifteen options to any of the five logic inputs for the L100 inverters. The functions C01through C05 configure the terminals 1 through 5 respectively. The “value” of these particular parameters is not a scalar value, but it is a discrete number that selects one option from two or more available *options*.

For example, if you set function C01=00, you have assigned option 00 (Forward Run) to terminal 1. The option codes and the specifics of how each one works are in Chapter 4.

“C” Function			Run-time Edit	Defaults		DOP,DRW,DOP+	
Func. Code	Name	Description		EU/ US	Units	Func. Code	Name
C01	Terminal 1 function	Select function for terminal 1 18 options (see next section)	✘	00	—	F34	IN-TM1
C02	Terminal 2 function	Select function for terminal 2 18 options (see next section)	✘	01/01	—	F34	IN-TM2
C03	Terminal 3 function	Select function for terminal 3 18 options (see next section)	✘	02/16	—	F34	IN-TM3
C04	Terminal 4 function	Select function for terminal 4 18 options (see next section)	✘	03/13	—	F34	IN-TM4
C05	Terminal 5 function	Select function for terminal 5 19 options (see next section)	✘	18/18	—	F34	IN-TM5

The input logic convention is programmable for each of the five inputs. Most inputs default to normally open (active high), but you can select normally closed (active low) in order to invert the sense of the logic.

"C" Function			Run-time Edit	Defaults		DOP,DRW,DOP+	
Func. Code	Name	Description		EU/ US	Units	Func. Code	Name
C11	Terminal 1 active state	Select logic convention, two option codes: 00...normally open [NO] 01...normally closed [NC]	✘	00	—	F34	IN-TM O/C-1
C12	Terminal 2 active state	Select logic convention, two option codes: 00...normally open [NO] 01...normally closed [NC]	✘	00	—	F34	IN-TM O/C-2
C13	Terminal 3 active state	Select logic convention, two option codes: 00...normally open [NO] 01...normally closed [NC]	✘	00	—	F34	IN-TM O/C-3
C14	Terminal 4 active state	Select logic convention, two option codes: 00...normally open [NO] 01...normally closed [NC]	✘	00/01	—	F34	IN-TM O/C-4
C15	Terminal 5 active state	Select logic convention, two option codes: 00...normally open [NO] 01...normally closed [NC]	✘	00	—	F34	IN-TM O/C-5

NOTE: An input terminal configured for option code 18 ([RS] Reset command) cannot be configured for normally closed operation.

Intelligent Input Terminal Overview

Each of the five intelligent terminals may be assigned any of the options in the following table. When you program one of the option codes for terminal assignments C01 to C05, the respective terminal assumes the function role of that option code. The terminal functions have a symbol or abbreviation, which we use to label a terminal using that function. For example the "Forward Run" command is [FWD]. The physical label on the terminal block connector is simply **1**, **2**, **3**, **4**, or **5**. However, schematic examples in this manual also use the terminal symbol (such as [FWD]) to show the assigned option. The option codes for C11 to C15 determines the active state of the logical input (active high or active low).

Summary Table - this table shows all fifteen intelligent input functions at a glance. Detailed descriptions of these functions, related parameters and settings, and example wiring diagrams are in Chapter 4, starting on page 4–6.

Input Function Summary Table				
Option Code	**Terminal Symbol**	**Function Name**	**Description**	
00	FW	Forward Run/Stop	ON	Inverter is in Run Mode, motor runs forward
			OFF	Inverter is in Stop Mode, motor stops
01	RV	Reverse Run/Stop	ON	Inverter is in Run Mode, motor runs reverse
			OFF	Inverter is in Stop Mode, motor stops
02	CF1	Multi-speed select, Bit 0 (LSB)	ON	Binary encoded speed select, Bit 0, logical 1
			OFF	Binary encoded speed select, Bit 0, logical 0
03	CF2	Multi-speed select, Bit 1	ON	Binary encoded speed select, Bit 1, logical 1
			OFF	Binary encoded speed select, Bit 1, logical 0
04	CF3	Multi-speed select, Bit 2	ON	Binary encoded speed select, Bit 2, logical 1
			OFF	Binary encoded speed select, Bit 2, logical 0
05	CF4	Multi-speed select, Bit 3 (MSB)	ON	Binary encoded speed select, Bit 3, logical 1
			OFF	Binary encoded speed select, Bit 3, logical 0
06	JG	Jogging	ON	Inverter is in Run Mode, output to motor runs at jog parameter frequency
			OFF	Inverter is in Stop Mode
09	2CH	2-stage Acceleration and Deceleration	ON	Frequency output uses 2nd-stage acceleration and deceleration values
			OFF	Frequency output uses standard acceleration and deceleration values
11	FRS	Free-run Stop	ON	Causes output to turn off, allowing motor to free run (coast) to stop
			OFF	Output operates normally, so controlled deceleration stops motor
12	EXT	External Trip	ON	When assigned input transitions Off to On, inverter latches trip event and displays E12
			OFF	No trip event for On to Off, any recorded trip events remain in history until Reset
13	USP	Unattended Start Protection	ON	On powerup, the inverter will not resume a Run command (mostly used in the US)
			OFF	On powerup, the inverter will resume a Run command that was active before power loss

Input Function Summary Table				
Option Code	**Terminal Symbol**	**Function Name**	**Description**	
15	SFT	Software Lock	ON	The keypad and remote programming devices are prevented from changing parameters
			OFF	The parameters may be edited and stored
16	AT	Analog Input Voltage/current Select	ON	Terminal OI is enabled for current input (uses terminal L for power supply return)
			OFF	Terminal O is enabled for voltage input (uses terminal L for power supply return)
18	RS	Reset Inverter	ON	The trip condition is reset, the motor output is turned off, and powerup reset is asserted
			OFF	Normal power-on operation
19	PTC	PTC Thermistor Thermal Protection	ANLG	When a thermistor is connected to terminals 5 and L, the inverter checks for over-temperature and will cause trip event and turn off output to motor
			OPEN	A disconnect of the thermistor causes a trip event, and the inverter turns off the motor

Output Terminal Configuration

The inverter provides configuration for logic (discrete) and analog outputs, shown in the table below.

"C" Function			Run-time Edit	Defaults		DOP,DRW,DOP+	
Func. Code	Name	Description		EU/ US	Units	Func. Code	Name
C21	Terminal 11 function (logical)	Select function for terminal 11, 6 options (see next section)	✘	01	—	F-35	OUT-TM 1
C22	Terminal 12 function (logical)	Select function for terminal 12, 6 options (see next section)	✘	00	—	F-35	OUT-TM 2
C23	Terminal FM function (analog)	Select function for terminal FM, 3 options (see next section)	✘	00	—	F-37	MONITOR

The output logic convention is programmable for terminals 11 and 12. The open-collector output terminals 11 and 12 default to normally open (active low), but you can select normally closed (active high) for terminals 11 and 12 in order to invert the sense of the logic. The relay already has normally open and normally closed contacts, but you can invert the logic sense of these as well.

"C" Function			Run-time Edit	Defaults		DOP,DRW,DOP+	
Func. Code	Name	Description		EU/ US	Units	Func. Code	Name
C31	Terminal 11 active state	Select logic convention, two option codes: 00...normally open [NO] 01...normally closed [NC]	✘	00	—	F-35	OUT-TM O/C-1
C32	Terminal 12 active state	Select logic convention, two option codes: 00...normally open [NO] 01...normally closed [NC]	✘	00	—	F-35	OUT-TM O/C-2
C33	Alarm relay active state	Select logic convention, two option codes: 00...normally open [NO] 01...normally closed [NC]	✘	01	—	F-35	OUT-TM O/C-RY

The output logic convention is programmable for terminals 11 and 12. The open-collector output terminals 11 and 12 default to normally open (active low), but you can select normally closed (active high) for terminals 11 and 12 in order to invert the sense of the logic.

"C" Function			Run-time Edit	Defaults		DOP,DRW,DOP+	
Func. Code	Name	Description		EU/ US	Units	Func. Code	Name
C31	Terminal 11 active state	Select logic convention, two option codes: 00...normally open [NO] 01...normally closed [NC]	✘	00	—	F-35	OUT-TM O/C-1
C32	Terminal 12 active state	Select logic convention, two option codes: 00...normally open [NO] 01...normally closed [NC]	✘	00	—	F-35	OUT-TM O/C-2
C33	Alarm relay active state	Select logic convention, two option codes: 00...normally open [NO] 01...normally closed [NC]	✘	01	—	F-35	OUT-TM O/C-RY

Summary Table - this table shows all six functions for the logical outputs (11, 12) at a glance. Detailed descriptions of these functions, related parameters and settings, and example wiring diagrams are in Chapter 4, starting on page 4–18.

Output Function Summary Table				
Option Code	Terminal Symbol	Function Name	Description	
00	RUN	Run signal	ON	when inverter is in Run Mode
			OFF	when inverter is in Stop Mode
01	FA1	Frequency arrival type 1 signal	ON	when output to motor is at the set frequency
			OFF	when output to motor is off, or in any acceleration or deceleration ramp
02	FA2	Frequency arrival type 2 signal	ON	when output to motor is at or above the set frequency, even if in accel. or decel. ramps
			OFF	when output to motor is off, or at a level below the set frequency
03	OL	Overload advance notice signal	ON	when output current is more than the set threshold for the overload signal
			OFF	when output current is less than the set threshold for the overload signal
04	OD	Output deviation for PID control	ON	when PID error is more than the set threshold for the deviation signal
			OFF	when PID error is less than the set threshold for the deviation signal

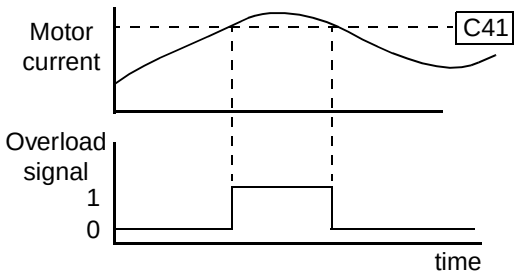
Output Function Summary Table				
Option Code	**Terminal Symbol**	**Function Name**	Description	
05	AL	Alarm signal	ON	when an alarm signal has occurred and has not been cleared
			OFF	when no alarm has occurred since the last clearing of alarm(s)

Analog Summary Table - this table shows all three functions for the analog output FM (frequency meter) terminal at a glance. Detailed descriptions, related parameters and settings, and example wiring diagrams are in Chapter 4, starting on page 4–24.

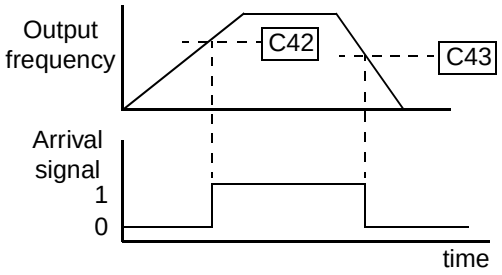
Analog Function Summary Table			
Option Code	**Terminal Symbol**	**Function Name**	Description
00	A-F	Analog frequency monitor	PWM (pulse-width-modulated) voltage output which has a duty cycle proportional to the inverter output frequency
01	A	Analog current output monitor	PWM (pulse-width-modulated) voltage output which has a duty cycle proportional to the inverter output current to the motor. It reaches 100% duty cycle when the output reaches 200% of the rated inverter current.
02	D	Digital frequency output monitor	FM (frequency-modulated) voltage output with a constant 50% duty cycle. Its frequency = inverter output frequency.

Output Function Adjustment Parameters

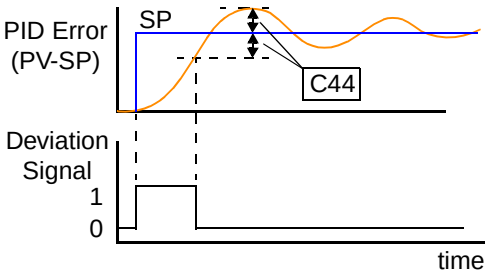
The overload level parameter (C41)sets the motor current level at which the overload signal becomes true. The range of settings is from 0% to 200% of the rated current for the inverter. This function is for generating an early warning logic output, without causing either a trip event or a restriction of the motor current (those effects are available on other functions).



The frequency arrival signal is intended to indicate when the inverter output has reached (arrived at) the target frequency. You can adjust the timing of the leading and trailing edges of the signal via two parameters specific to acceleration and deceleration ramps, C42 and C43.



The Error for the PID loop is the magnitude (absolute value) of the difference between the Setpoint (desired value) and Process Variable (actual value). The PID output deviation signal (output terminal function option code 04) indicates when the error magnitude has exceeded a magnitude you define.



"C" Function			Run-time Edit	Defaults		DOP,DRW,DOP+	
Func. Code	Name	Description		EU/ US	Units	Func. Code	Name
C41	Overload level setting	Sets the overload signal level between 0% and 200% (from 0 to two times the rated current of the inverter)	✘	(rated current for each inverter)		F-33	OV Load
C42	Frequency arrival setting for accel.	Sets the frequency arrival setting threshold for the output frequency during acceleration	✘	0.0	Hz	F-32	ARV ACC
C43	Arrival frequency setting for decel.	Sets the frequency arrival setting threshold for the output frequency during deceleration	✘	0.0	Hz	F-32	ARV DEC
C44	PID deviation level setting	Sets the allowable PID loop error magnitude (absolute value), SP - PV, range is 0.0 to 100%, resolution is 0.1%	✘	3.0	%	F-33	OV PID

"C" Function			Run-time Edit	Defaults		DOP,DRW,DOP+	
Func. Code	Name	Description		EU/ US	Units	Func. Code	Name
C81	Analog meter adjustment, voltage input	Scale factor between the external frequency command on terminals L – O (voltage input) and the frequency output	✘		—	Mon.	ADJ-O
C82	Analog meter adjustment, current input	Scale factor between the external frequency command on terminals L – OI (current input) and the frequency output	✘		—	Mon.	ADJ-OI
C91	Debug mode selection	(Reserved) DO NOT EDIT	✘	00	—	—	—

Operations and Monitoring

4

In This Chapter.... page

Introduction

The previous chapter gave a reference listing of all the programmable functions of the inverter. We suggest that you first scan through the previous chapter's listing of inverter functions to gain a general familiarity. This chapter will build on that knowledge in the following ways:

1. **Related functions** – Some parameters interact with or depend on the settings in other functions. This chapter lists "required settings" for a programmable function to serve as a cross-reference and an aid in showing how functions interact.
2. **Intelligent terminals** – Some functions rely on an input signal on a control logic connector terminal, or generate output signals in other cases.
3. **Electrical interfaces** – This chapter shows how to make connections between the inverter and other electrical devices.
4. **PID Loop Operation** – the L100 has a built-in PID loop that calculates the optimal inverter output frequency to control an external process. This chapter shows the parameters and input/output terminals associated with PID loop operation.
5. **Multiple motors** – a single L100 inverter may be used with two or more motors in some types of applications. This chapter shows the electrical connections involved in multiple-motor applications.

The topics in this chapter can help you decide which features are important to your application, and how to use them. The basic installation covered in Chapter 2 concluded with the powerup test and running the motor. Now, this chapter starts from that point and shows how to make the inverter part of a larger control or automation system.

Before continuing, please read the following safety messages.

Caution Messages for Operating Procedures

CAUTION: The heat sink fins will have a high temperature. Be careful not to touch them. Otherwise, there is the danger of getting burned.

CAUTION: The operation of the inverter can be easily changed from low speed to high speed. Be sure check the capability and limitations of the motor and machine before operating the inverter. Otherwise, it may cause injury to personnel.

CAUTION: If you operate a motor at a frequency higher than the inverter standard default setting (50Hz/60Hz), be sure to check the motor and machine specifications with the respective manufacturer. Only operate the motor at elevated frequencies after getting their approval. Otherwise, there is the danger of equipment damage.

Warning Messages for Operating Procedures

WARNING: Be sure to turn on the input power supply after closing the front case. While being energized, be sure not to open the front case. Otherwise, there is the danger of electric shock.

WARNING: Be sure not to operate the switches with wet hands. Otherwise, there is the danger of electric shock.

WARNING: While the inverter is energized, be sure not to touch the inverter terminals even when the motor is stopped. Otherwise, there is the danger of electric shock.

WARNING: If the Retry Mode is selected, the motor may suddenly restart during the trip stop. Do not approach the machine (be sure to design the machine so that safety for personnel is secure even if it restarts.) Otherwise, it may cause injury to personnel.

WARNING: If the power supply is cut off for a short period of time, the inverter may restart operation after the power supply recovers if the command to operate is active. If a restart may pose danger to personnel, so be sure to use a lock-out circuit so that it will not restart after power recovery. Otherwise, it may cause injury to personnel.

WARNING: The Stop Key is effective only when the Stop function is enabled. Be sure to enable the Key separately from the emergency stop. Otherwise, it may cause injury to personnel.

WARNING: After the operation command is given, if the alarm reset is conducted, it will restart suddenly. Be sure to set the alarm reset after verifying the operation command is off. Otherwise, it may cause injury to personnel.

WARNING: Be sure not to touch the inside of the energized inverter or to put any conductive object into it. Otherwise, there is a danger of electric shock and/or fire.

WARNING: When the power is turned on when the running command is already active, the motor will suddenly start rotation and is dangerous. Before turning the power on, confirm that the running command is not enabled.

WARNING: When the Stop key function is disabled, pressing the Stop key does not cancel the stop and trip.

WARNING: Be sure to provide a separate, hard-wired emergency stop switch. When the operation command source is a digital operator, this selection is ineffective.

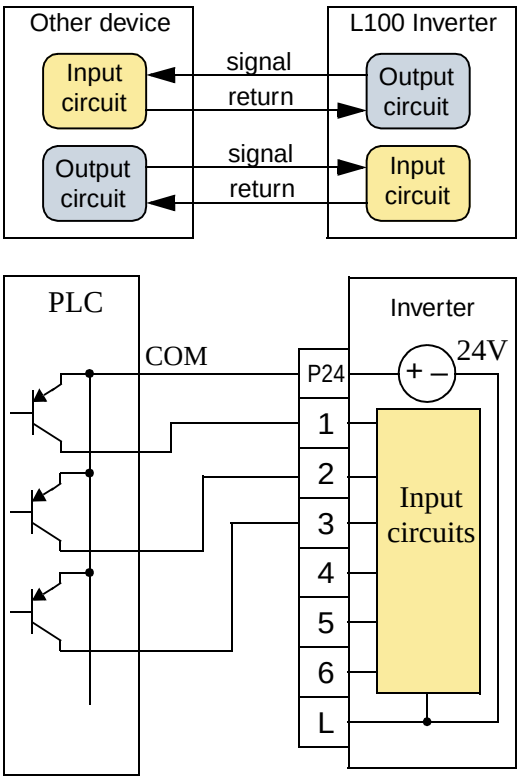
Connecting to PLCs and Other Devices

Hitachi inverters (drives) are useful in many types of applications. During installation, the inverter keypad (or other programming device) will facilitate the initial configuration. After installation, the inverter will generally receive its control commands through the control logic connector or serial interface from another controlling device. In a simple application such as single-conveyor speed control, a Run/Stop switch and potentiometer will give the operator all the required control. In a sophisticated application, you may have a *programmable logic controller* (PLC) as the system controller, with several connections to the inverter.

The variety of applications is practically endless, and is beyond the scope of this manual. It will be important for you to know the electrical characteristics of the devices you want to connect to the inverter. Then, this section and the following sections on I/O terminal functions can help you quickly and safely connect those devices to the inverter.

CAUTION: It is possible to damage the inverter or other devices in your application if the maximum current or voltage characteristics of a connection point are exceeded.

The connections between the inverter and other devices rely on the electrical input/output characteristics at both ends of each connection, shown in the diagram to the right. The inverter's inputs require a sourcing output from an external device (such as a PLC). This chapter shows the inverter's internal electrical component(s) at each I/O terminal. In some cases, you will need to insert a power source in the interface wiring.



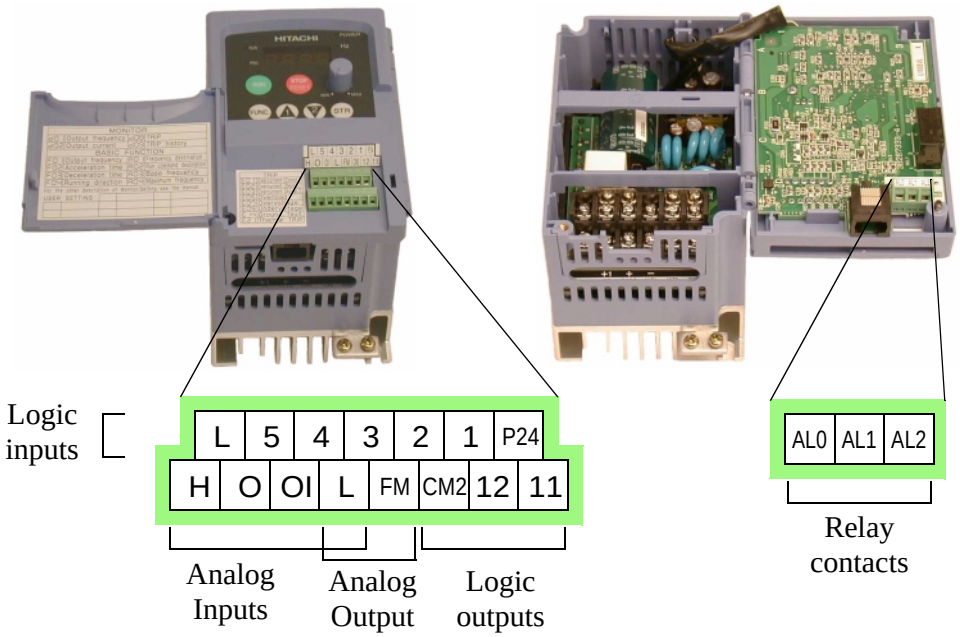
In order to avoid equipment damage and get your application running smoothly, we recommend drawing a schematic of each connection between the inverter and the other device. Include the internal components of each device in the schematic, so that it makes a complete circuit loop.

After making the schematic, then:

1. Verify that the current and voltage for each connection is within the operating limits of each device.
2. Make sure that the logic sense (active high or active low) of any ON/OFF connection is correct.
3. Check the zero and span (curve end points) for analog connections, and be sure the scale factor from input to output is correct.
4. Understand what will happen at the system level if any particular device suddenly loses power, or powers up after other devices.

Specifications of Control and Logic Connections

The control logic connectors are located just behind the front panel half-door. The relay contacts are accessible behind the main door. Connector labeling is shown below.



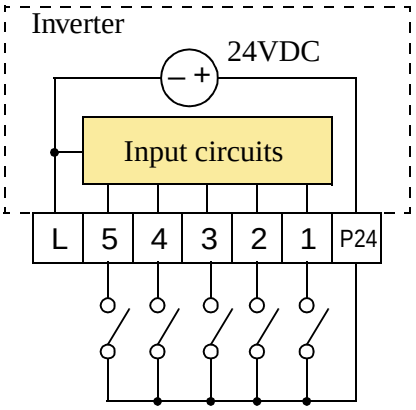
Specifications for the logic connection terminals are in the following table:

Terminal Name	Description	Ratings
P24	+24V for logic inputs	24VDC, 30 mA max (do not short to terminal L)
1, 2, 3, 4, 5	Discrete logic inputs	27VDC max. (use P24 or an external supply referenced to terminal L)
L (top row) *1	GND for logic inputs	sum of input 1-6 currents (return)
11, 12	Discrete logic outputs	50mA maximum ON state current, 27 VDC maximum OFF state voltage
CM2	GND for logic outputs	100 mA: sum of 11 and 12 currents (return)
FM	PWM (analog/digital) output	0 to 10VDC, 1 mA, PWM and 50% duty digital
L (bottom row) *1	GND for analog inputs	sum of OI, O, and H currents (return)
OI	Analog input, current	4 to 19.6 mA range, 20 mA nominal
O	Analog input, voltage	0 to 9.6 VDC range, 10VDC nominal, input impedance 10 kΩ
H	+10V analog reference	10VDC nominal, 10 mA max
AL0	Relay common contact	250 VAC, 2.5A (R load) max., 250 VAC, 0.2A (I load, P.F=0.4) max. 100 VAC, 10mA min. 30 VDC, 3.0A (R load) max. 30 VDC, 0.7A (I load, P.F.=0.4) max. 5 VDC, 100mA min.
AL1	Relay contact, normally closed during RUN	
AL2	Relay contact, normally open during RUN	

Note 1: The two terminals “L” are electrically connected together inside the inverter.

Using Intelligent Input Terminals

Terminals 1, 2, 3, 4, and 5 are identical, programmable inputs for general use. The input circuits can use the inverter's internal (isolated) +24V field supply (P24) to power the inputs. The input circuits are internally connected to the power supply ground. As the diagram shows, you can use a switch (or jumper) to activate an input terminal which has been programmed. If you use an external supply, its GND terminal must connect to the "L" terminal on the inverter to complete the input circuit. We recommend using the top row "L" logic GND for login input circuits and the "L" GND on the bottom row of terminals for analog I/O circuits.



Forward Run/Stop and Reverse Run/Stop Commands:

When you input the Run command via the terminal [FW], the inverter executes the Forward Run command (high) or Stop command (low). When you input the Run command via the terminal [RV], the inverter executes the Reverse Run command (high) or Stop command (low).

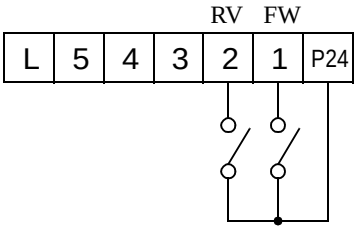
Option Code	Terminal Symbol	Function Name	State	Description
00	FW	Forward Run/Stop	ON	Inverter is in Run Mode, motor runs forward
			OFF	Inverter is in Stop Mode, motor stops
01	RV	Reverse Run/Stop	ON	Inverter is in Run Mode, motor runs reverse
			OFF	Inverter is in Stop Mode, motor stops

Valid for inputs:	C01, C02, C03, C04, C05
Required settings:	A02 = 01

Notes:

- When the Forward Run and Reverse Run commands are active at the same time, the inverter enters the Stop Mode.
- When a terminal associated with either [FW] or [RV] function is configured for *normally closed*, the motor starts rotation when that terminal is disconnected or otherwise has no input voltage.

Example:



See I/O specs on page 4–5.

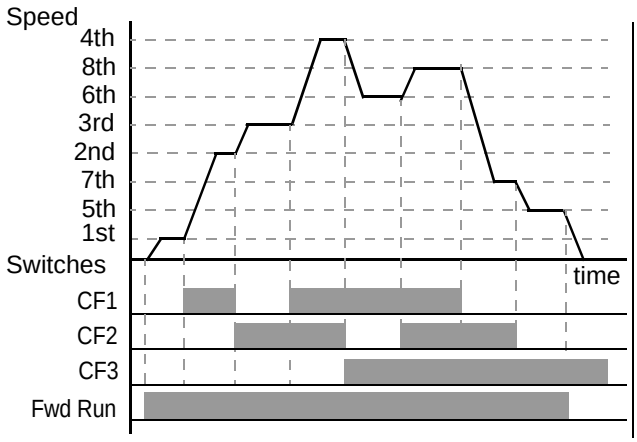
WARNING: If the power is turned on and the Run command is already active, the motor starts rotation and is dangerous! Before turning power on, confirm that the Run command is not active.

Multi-Speed Select

The inverter provides storage parameters for up to 16 different target frequencies (speeds) that the motor output uses for steady-state run condition. These speeds are accessible through programming four of the intelligent terminals as binary-encoded inputs CF1 to CF4 per the table below. These can be any of the five inputs, and in any order. You can use fewer inputs if you need eight or less speeds.

Note: When choosing a subset of speeds to use, always start at the top of the table, and with the least-significant bit: CF1, CF2, etc.

The figure below shows how input switches configured with CF1 functions can change the motor speed in real time.



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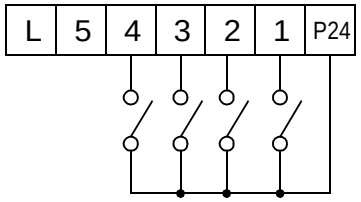
Multi-speed	Input Function			
	CF4	CF3	CF2	CF1
Speed 1	0	0	0	0
Speed 2	0	0	0	1
Speed 3	0	0	1	0
Speed 4	0	0	1	1
Speed 5	0	1	0	0
Speed 6	0	1	0	1
Speed 7	0	1	1	0
Speed 8	0	1	1	1
Speed 9	1	0	0	0
Speed 10	1	0	0	1
Speed 11	1	0	1	0
Speed 12	1	0	1	1
Speed 13	1	1	0	0
Speed 14	1	1	0	1
Speed 15	1	1	1	0
Speed 16	1	1	1	1

NOTE: Speed 1 is set by the A01 parameter value.

Option Code	Terminal Symbol	Function Name	Input State	Description
02	CF1	Multi-speed select, Bit 0 (LSB)	ON	Binary encoded speed select, Bit 0, logical 1
			OFF	Binary encoded speed select, Bit 0, logical 0
03	CF2	Multi-speed select, Bit 1	ON	Binary encoded speed select, Bit 1, logical 1
			OFF	Binary encoded speed select, Bit 1, logical 0
04	CF3	Multi-speed select, Bit 2	ON	Binary encoded speed select, Bit 2, logical 1
			OFF	Binary encoded speed select, Bit 2, logical 0
05	CF4	Multi-speed select, Bit 3 (MSB)	ON	Binary encoded speed select, Bit 3, logical 1
			OFF	Binary encoded speed select, Bit 3, logical 0

Option Code	Terminal Symbol	Function Name	Input State	Description
Valid for inputs:		C01, C02, C03, C04, C05		Example: (MSB) CF4 CF3 CF2 CF1 (LSB) L 5 4 3 2 1 P24 
Required settings:		F01, A20 to A35		
Notes: • When programming the multi-speed settings, be sure to press the Store key each time and then set the next multi-speed setting. Note that when the key is not pressed, no data will be set. • When a multi-speed setting more than 50Hz(60Hz) is to be set, it is necessary to program the maximum frequency A04 high enough to allow that speed.				See I/O specs on page 4–5.

While using the multi-speed capability, you can monitor the current frequency with monitor function D01 during each segment of a multi-speed operation.
There are two ways to program the speeds into the registers A20 to A35:

1. Standard keypad programming:

a. Select each parameter A20 to A35.

b. Press the FUNC key to view the parameter value.

c. Use the ▲1 and ▼2 keys to edit the value.

d. Use the STR key to save the data to memory.

2. Programming using the CF switches. Set the speed by following these steps:

a. Turn the Run command off (Stop Mode).

b. Turn each switch on and set it to Multi-speed n. Display the data section of F01.

c. Set an optional output frequency by pressing the ▲1 and ▼2 keys.

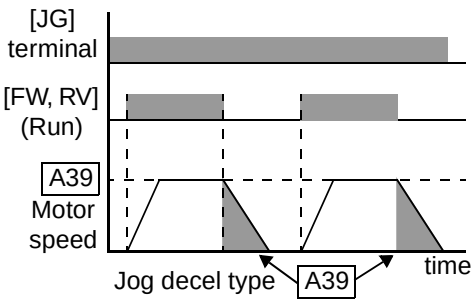
d. Press the STR key once to store the set frequency. When this occurs, F01 indicates the output frequency of Multi-speed n.

e. Press the FUNC key once to confirm that the indication is the same as the set frequency.

f. When you repeat operations in 2. a) to 2. e), the frequency of Multi-speed n can be set. It can be set also by parameters A20 to A35 in the first procedure 1. a) to 1. d).

Jogging Command

When the terminal [JG] is turned on and the Run command is issued, the inverter outputs the programmed jog frequency to the motor. Use a switch between terminals [JG] and [P24] to activate the JG frequency.

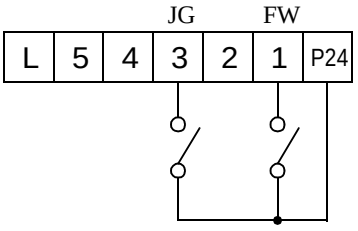


The frequency for the jogging operation is set by parameter A38.

Set the value 01(terminal mode) in A02 (Run command). Since jogging does not use an acceleration ramp, we recommend setting the jogging frequency in A38 to 5 Hz or less to prevent tripping.

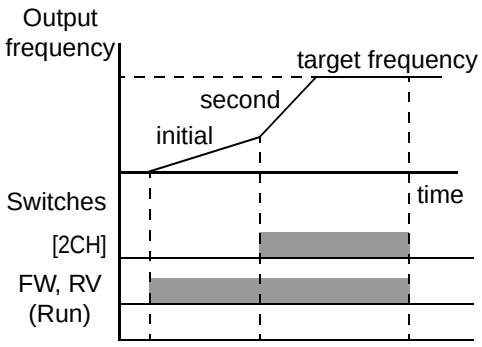
The type of deceleration used to end a motor jog is selectable by programming function A39. The options are:

- 00 Free-run stop (coasting)
- 01 Deceleration (normal level) and stop
- 02 Use DC braking and stop

Option Code	Terminal Symbol	Function Name	Input State	Description
06	JG	Jogging	ON	Inverter is in Run Mode, output to motor runs at jog parameter frequency
			OFF	Inverter is in Stop Mode
Valid for inputs:		C01, C02, C03, C04, C05		Example: 
Required settings:		A02= 01, A38 > B82, A38 > 0, A39		
Notes: • No jogging operation is performed when the set value of jogging frequency A38 is smaller than the start frequency B82, or the value is 0 Hz. • Be sure to stop the motor when switching the function [JG] On or Off.				See I/O specs on page 4–5.

Two-stage Acceleration and Deceleration

When terminal [2CH] is turned on, the inverter changes the rate of acceleration and deceleration from the initial settings (F02 and F03) to use the second set of acceleration/ deceleration values. When the terminal is turned off, the equipment is returned to the original acceleration and deceleration time (F02 acceleration time 1, and F03 deceleration time 1). Use A92 (acceleration time 2) and A93 (deceleration time 2) to set the second stage acceleration and deceleration times.



In the graph shown above, the [2CH] becomes active during the initial acceleration. This causes the inverter to switch from using acceleration 1 (F02) to acceleration 2 (A92).

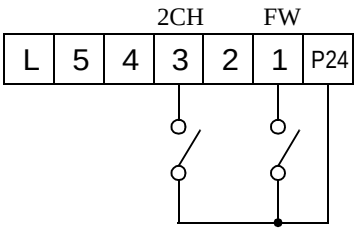
Option Code	Terminal Symbol	Function Name	Input State	Description
09	2CH	Two-stage Acceleration and Deceleration	ON	Frequency output uses 2nd-stage acceleration and deceleration values
			OFF	Frequency output uses the initial acceleration 1 and deceleration 1 values

Valid for inputs:	C01, C02, C03, C04, C05
Required settings:	A92, A93, A94=0

Notes:

- Function A94 selects the method for second stage acceleration. It must be 00 to select the input terminal method in order for the 2CH terminal assignment to operate.

Example:



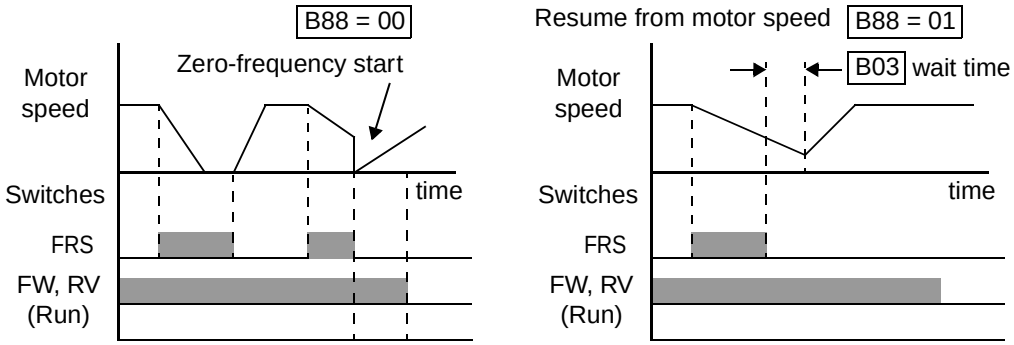
See I/O specs on page 4–5.

Free-run Stop

When the terminal [FRS] is turned on, the inverter stops the output and the motor enters the free-run state (coasting). If terminal [FRS] is turned off, the output resumes sending power to the motor if the Run command is still active. The free-run stop feature works with other parameters to provide flexibility in stopping and starting motor rotation.

In the figure below, parameter B88 selects whether the inverter resumes operation from 0 Hz (left graph) or the current motor rotation speed (right graph) when the [FRS] terminal turns off. The application determines which is the best setting.

Parameter B03 specifies a delay time before resuming operation from a free-run stop. To disable this feature, use a zero delay time.



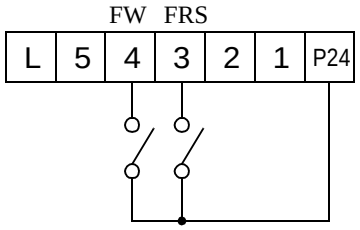
Option Code	Terminal Symbol	Function Name	Input State	Description
11	FRS	Free-run Stop	ON	Causes output to turn off, allowing motor to free run (coast) to stop
			OFF	Output operates normally, so controlled deceleration stops motor

Valid for inputs:	C01, C02, C03, C04, C05
Required settings:	B03, B88, C11 to C15

Notes:

- When you want the [FRS] terminal to be active low (normally closed logic), change the setting (C11 to C15) which corresponds to the input (C01 to C05) that is assigned the [FRS] function.

Example:

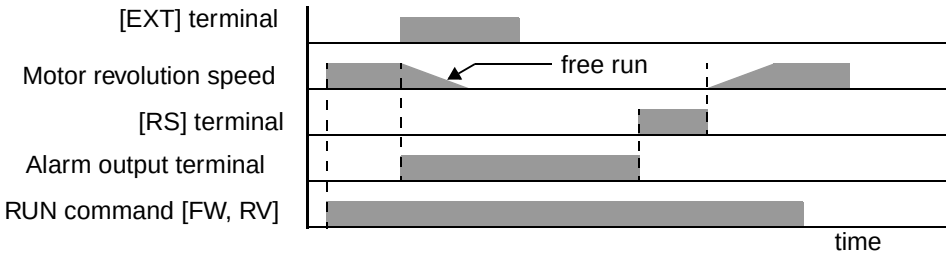


See I/O specs on page 4–5.

External Trip

When the terminal [EXT] is turned on, the inverter enters the trip state, indicates error code E12, and stops the output. This is a general purpose interrupt type feature, and the meaning of the error depends on what you connect to the [EXT] terminal. When the switch between the set terminals [EXT] and [P24] is turned on, the equipment enters the trip state. Even when the switch to [EXT] is turned off, the inverter remains in the trip state. You must reset the inverter or cycle power to clear the error, returning the inverter to the Stop Mode.

In the graph below, the [EXT] input turns on during normal Run Mode operation. The inverter lets the motor free-run to a stop, and the alarm output turns on immediately. When the operator initiates a Reset command, the alarm and error are cleared. When the Reset is turned off, the motor begins rotation since the Run command is already active.



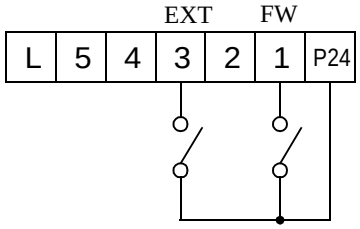
Option Code	Terminal Symbol	Function Name	Input State	Description
12	EXT	External Trip	ON	When assigned input transitions Off to On, inverter latches trip event and displays E12
			OFF	No trip event for On to Off, any recorded trip events remain in history until Reset

Valid for inputs:	C01, C02, C03, C04, C05
Required settings:	(none)

Notes:

- If the USP (Unattended Start Protection) feature is in use, the inverter will not automatically restart after cancelling the EXT trip event. In that case, it must receive another Run command (off-to-on transition).

Example:

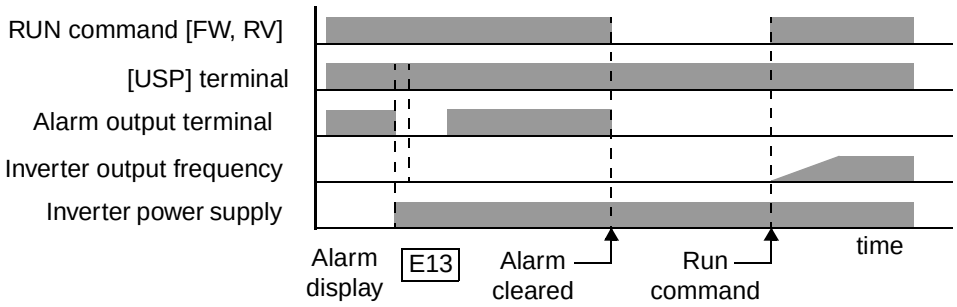


See I/O specs on page 4–5.

Unattended Start Protection

If the Run command is already set when power is turned on, the inverter starts running immediately after powerup. The Unattended Start Protection (USP) function prevents that automatic startup, so that the inverter *will not* run without outside intervention. To reset an alarm and restart running, turn the Run command off or perform a reset operation by the terminal [RS] input or the keypad Stop/reset key.

In the figure below, the [UPS] feature is enabled. When the inverter power turns on, the motor does not start, even though the Run command is already active. Instead, it enters the USP trip state, and displays E13 error code. This forces outside intervention to reset the alarm by turning off the Run command. Then the Run command can turn on again and start the inverter output.



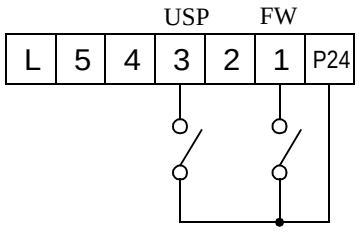
Option Code	Terminal Symbol	Function Name	Input State	Description
13	USP	Unattended Start Protection	ON	On powerup, the inverter will not resume a Run command (mostly used in the US)
			OFF	On powerup, the inverter will resume a Run command that was active before power loss

Valid for inputs:	C01, C02, C03, C04, C05
Required settings:	(none)

Notes:

- Note that when a USP error occurs and it is canceled by a reset from a [RS] terminal input, the inverter restarts running immediately.
- Even when the trip state is canceled by turning the terminal [RS] on and off after an under voltage protection E09 occurs, the USP function will be performed.
- When the running command is active immediately after the power is turned on, a USP error will occur. When this function is used, wait for at least three (3) seconds after the powerup to generate a Run command.

Example:



See I/O specs on page 4–5.

Software Lock

When the terminal [SFT] is turned on, the data of all the parameters and functions except the output frequency is locked (prohibited from editing). When the data is locked, the keypad keys cannot edit inverter parameters. To edit parameters again, turn off the [SFT] terminal input.

Use parameter B31 to select whether the output frequency is excluded from the lock state or is locked as well.

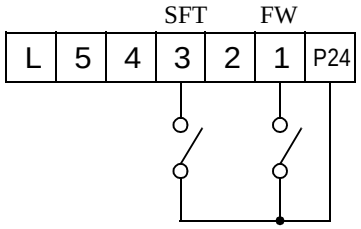
Option Code	Terminal Symbol	Function Name	Input State	Description
15	SFT	Software Lock	ON	The keypad and remote programming devices are prevented from changing parameters
			OFF	The parameters may be edited and stored

Valid for inputs:	C01, C02, C03, C04, C05
Required settings:	B31 (excluded from lock)

Notes:

- When the [SFT] terminal is turned on, only the output frequency can be changed.
- Software lock can be made possible also for the output frequency by B31.
- Software lock by the operator is also possible without the [SFT] terminal being used (B31).

Example:



See I/O specs on page 4–5.

Analog Input Current/Voltage Select

The [AT] terminal selects whether the inverter uses the voltage [O] or current [OI] input terminals for external frequency control. When the switch between the terminals [AT] and [P24] is on, it is possible to set the output frequency by applying a current input signal at [OI]-[L]. When the terminal is turned off, the voltage input signal at [O]-[L] is available. Note that you must also set parameter A1 = 01 to enable the analog terminal set for controlling the inverter frequency.

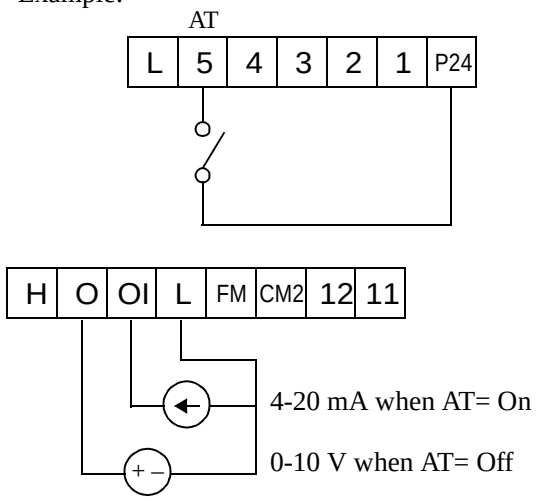
Option Code	Terminal Symbol	Function Name	Input State	Description
16	AT	Analog Input Voltage/current Select	ON	Terminal OI is enabled for current input (uses terminal L for power supply return)
			OFF	Terminal O is enabled for voltage input (uses terminal L for power supply return)

Valid for inputs:	C01, C02, C03, C04, C05
Required settings:	A01 = 01

Notes:

- If the [AT] option is not assigned to any intelligent input terminal, then inverter uses the algebraic sum of both the voltage and current inputs for the frequency command (and A01=01).
- When using either the analog current and voltage input terminal, make sure that the [AT] function is allocated to an intelligent input terminal.
- Be sure to set the frequency source setting A01=01 to select the analog input terminals.

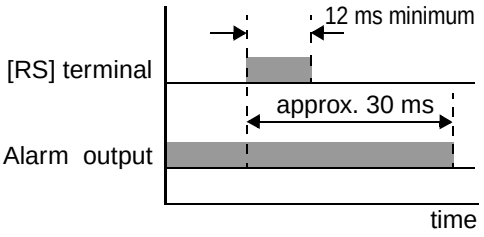
Example:



See I/O specs on page 4–5.

Reset Inverter

The [RS] terminal causes the inverter to execute the reset operation. If the inverter is in Trip Mode, the reset cancels the Trip state. When the switch between the set terminals [RS] and [P24] is turned on and off, the inverter executes the reset operation. The input timing requirement for [RST] needs a 12 ms pulse width or greater. The alarm output will be cleared within 30 ms after the onset of the Reset command.

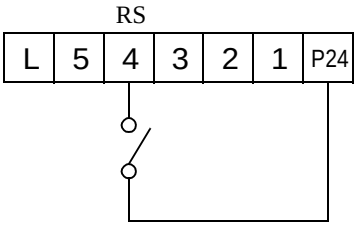


WARNING: After the Reset command is given and the alarm reset occurs, the motor will restart suddenly if the Run command is already active. Be sure to set the alarm reset after verifying that the Run command is off to prevent injury to personnel.

Option Code	Terminal Symbol	Function Name	Input State	Description
18	RS	Reset Inverter	ON	The motor output is turned off, the Trip Mode is cleared (if it exists), and powerup reset is applied
			OFF	Normal power-on operation

Valid for inputs:	C01, C02, C03, C04, C05
Required settings:	(none)

Example:



See I/O specs on page 4–5.

Notes:

- When the control terminal [RS] input is already On at powerup for more than 4 seconds, the remote operator display is “R-ERROR COMM<2>” (the display of the digital operator [OPE-J] is – – –. However, the inverter has no error. To clear the digital operator error, turn off the terminal [RS] input and press one of the operator keys.
- When the [RS] terminal is turned off from on, the Reset command is active.
- The Stop/Reset key of the digital operator is valid only when an alarm occurs.
- Only the normally open contact can be set for a terminal configured with the [RS] function. The terminal cannot be used in the normally closed contact state.
- Even when power is turned off or on, the function of the terminal is the same as that of the reset terminal.
- The Stop/Reset key on the inverter is only operational for a few seconds after inverter powerup when a hand-held remote operator is connected to the inverter.
- If the [RS] terminal is turned on while the motor is running, the motor will be free running (coasting).

PTC Thermistor Thermal Protection

Motors that are equipped with a thermistor can be protected from overheating. Input terminal 5 has the unique ability to sense a thermistor voltage. When the resistance value of the thermistor connected to terminal [PTC] (5) and [L] is more than 3 k Ohms ± 10%, the inverter enters the Trip Mode, turns off the output to the motor, and indicates the trip status E35. Use this function to protect the motor from overheating

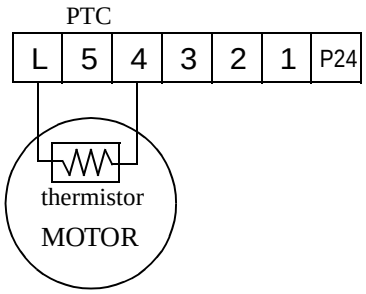
Option Code	Terminal Symbol	Function Name	Input State	Description
19	PTC	PTC Thermistor Thermal Protection	ANLG	When a thermistor is connected to terminals 5 and L, the inverter checks for over-temperature and will cause trip event and turn off output to motor
			OPEN	A disconnect of the thermistor causes a trip event, and the inverter turns off the motor

Valid for inputs:	C05 only
Required settings:	(none)

Notes:

- This function is assigned to the input terminal 5 only. If this function is assigned without connection the thermistor, the inverter automatically enters the Trip Mode. Be sure the thermistor is connected to terminals 5 and L, and then restart.

Example:

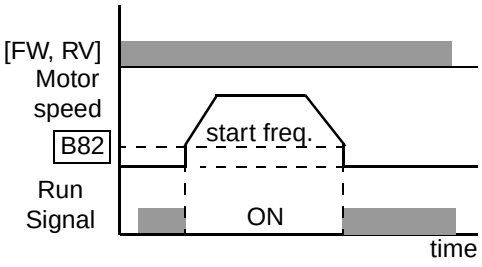


Using Intelligent Output Terminals

The intelligent output terminals are programmable in a similar way to the intelligent input terminals. The inverter has several output functions which you can assign individually to three physical logic outputs. Two of the outputs are open-collector transistors, and the third output is the alarm relay (form C – normally open and normally closed contacts). The relay is assigned the alarm function by default, but you can assign it to any of the functions that the open-collector outputs can use as well.

Run Signal

When the [RUN] signal is selected as an intelligent output terminal, the inverter outputs a signal on that terminal when it is in the Run Mode. The output logic is active low, and is the open collector type (switch to ground).



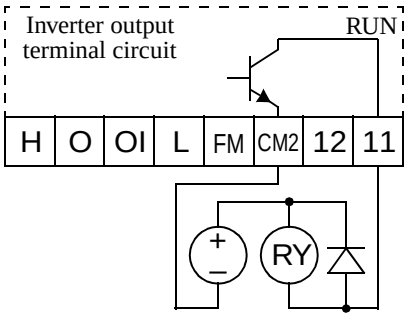
Option Code	Terminal Symbol	Function Name	Output State	Description
00	RUN	Run signal	ON	when inverter is in Run Mode
			OFF	when inverter is in Stop Mode

Valid for outputs:	11, 12, AL0 – AL2
Required settings:	(none)

Notes:

- The inverter outputs the [RUN] signal whenever the inverter output exceeds the start frequency specified by parameter B82. The start frequency is the initial inverter output frequency when it turns on.

Example:



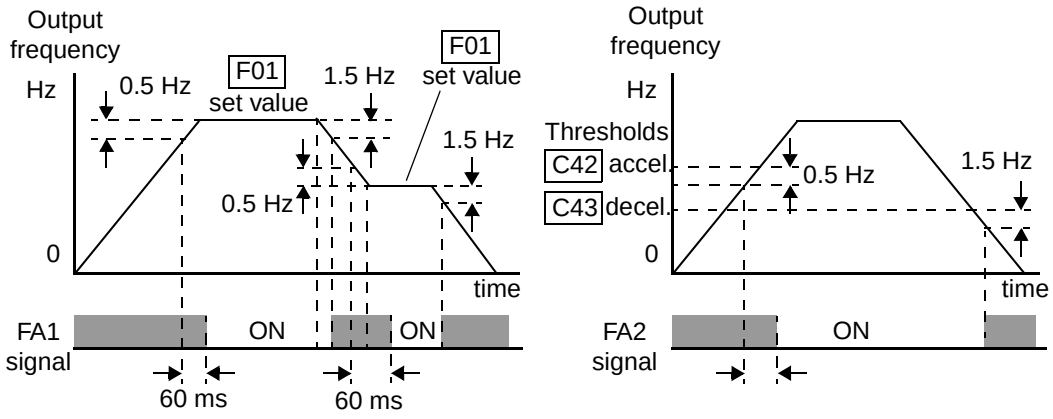
See I/O specs on page 4–5.

NOTE: The example circuit in the table above drives a relay coil. Note the use of a diode to prevent the negative-going turn-off spike generated by the coil from damaging the inverter's output transistor.

Frequency Arrival Signal

Frequency Arrival [FA1] and [FA2] signals indicate when the output frequency accelerates or decelerates to arrive at a constant frequency. Refer to the figure below. Frequency Arrival [FA1] (left graph) turns on when the output frequency gets within 0.5 Hz below or 1.5 Hz above the target constant frequency. The timing is modified by a small 60 ms delay. Note the active low nature of the signal, due to the open collector output.

Frequency Arrival [FA2] (right graph) uses thresholds for acceleration and deceleration to provide more timing flexibility than [FA1]. Parameter C42 sets the arrival frequency threshold for acceleration, and parameter C43 sets the threshold for deceleration. This signal also is active low and has a 60 ms delay after the frequency thresholds are crossed.



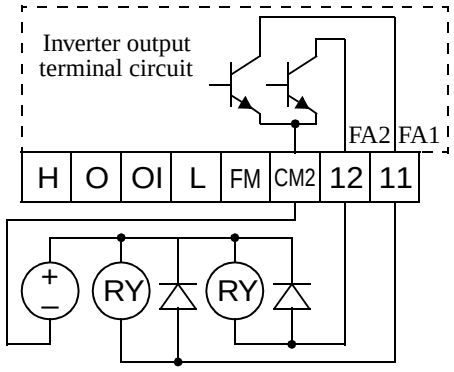
Option Code	Terminal Symbol	Function Name	Output State	Description
01	FA1	Frequency arrival type 1 signal	ON	when output to motor is at the set frequency
			OFF	when output to motor is off, or in any acceleration or deceleration ramp
02	FA2	Frequency arrival type 2 signal	ON	when output to motor is at or above the set frequency thresholds for, even if in acceleration or deceleration ramps
			OFF	when output to motor is off, or during acceleration or deceleration before the respective thresholds are crossed

Valid for outputs:	11, 12, AL0 – AL2
Required settings:	(none)

Notes:

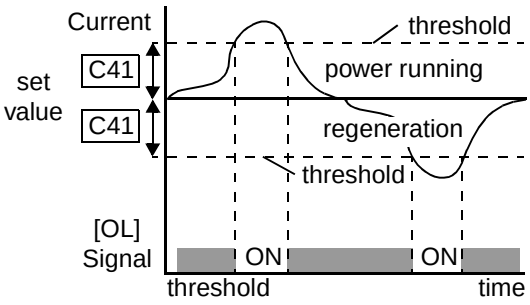
- At the time of acceleration, an output signal at a frequency between the set frequency - 0.5 Hz to + 1.5 Hz is turned on.
- At the time of deceleration, an output signal at a frequency between the set frequency + 0.5 Hz to -1.5 Hz is turned on.
- The delay time of the output signal is 60 ms (nominal).

Example: See I/O specs on page 4–5.



Overload Advance Notice Signal

When the output current exceeds a preset value, the [OL] terminal signal turns on. The parameter C41 sets the overload threshold. The overload detection circuit operates during powered motor operation and during regenerative braking. The output circuits use open-collector transistors, and are active low.



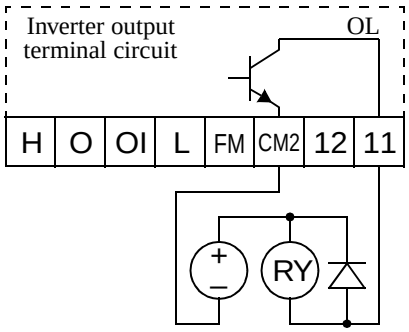
Option Code	Terminal Symbol	Function Name	Output State	Description
03	OL	Overload advance notice signal	ON	when output current is more than the set threshold for the overload signal
			OFF	when output current is less than the set threshold for the overload signal

Valid for outputs:	11, 12, AL0 – AL2
Required settings:	C41

Notes:

- The default value is 100%. To change the level from the default, set C41 (overload level).
- The accuracy of this function is the same as the function of the output current monitor on the [FM] terminal (see page 4–25).

Example:

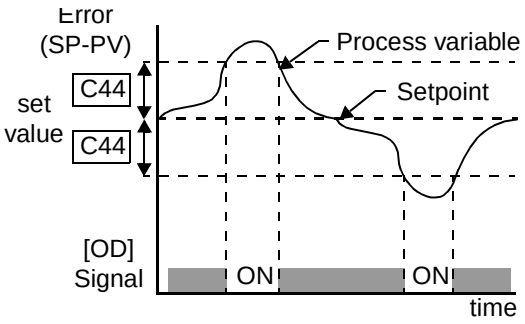


See I/O specs on page 4–5.

NOTE: The example circuit in the table above drives a relay coil. Note the use of a diode to prevent the negative-going turn-off spike generated by the coil from damaging the inverter's output transistor.

Output Deviation for PID Control

The PID loop error is defined as the magnitude (absolute value) of the difference between the Setpoint (target value) and the Process Variable (actual value). When the error magnitude exceeds the preset value for C44, the [OD] terminal signal turns on. Refer to the PID loop section on page 4–27 for more on PID loop operation.



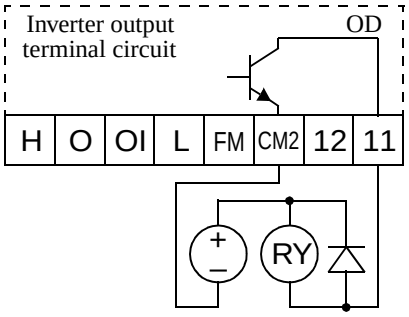
Option Code	Terminal Symbol	Function Name	Output State	Description
04	OD	Output deviation for PID control	ON	when PID error is more than the set threshold for the deviation signal
			OFF	when PID error is less than the set threshold for the deviation signal

Valid for outputs:	11, 12, AL0 – AL2
Required settings:	C44

Notes:

- The default difference value is set to 3%. To change this value, change parameter C44 (deviation level).

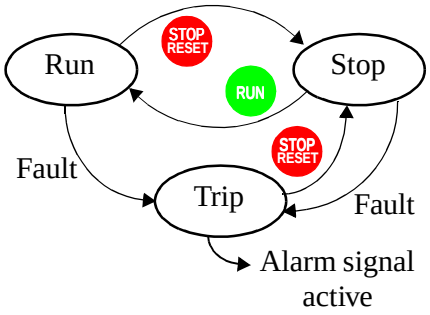
Example:



See I/O specs on page 4–5.

NOTE: The example circuit in the table above drives a relay coil. Note the use of a diode to prevent the negative-going turn-off spike generated by the coil from damaging the inverter's output transistor.

Alarm Signal



The inverter alarm signal is active when a fault has occurred and it is in the Trip Mode (refer to the diagram at right). When the fault is cleared the alarm signal becomes inactive.

We must make a distinction between the alarm *signal* [AL] and the alarm relay *contacts* AL0, AL1 and AL2. The signal [AL] is a logic function which you can assign to the open collector output terminals 11, or 12, or the relay outputs. The most common (and default) use of the relay is for [AL], thus the labeling of its terminals. Use an open collector output (terminal 11 or 12) for a low-current logic signal interface or to energize a small relay (50 mA maximum). Use the relay output to interface to higher voltage and current devices (10 mA minimum).

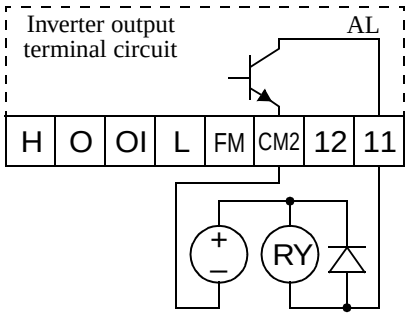
Option Code	Terminal Symbol	Function Name	Output State	Description
05	AL	Alarm signal	ON	when an alarm signal has occurred and has not been cleared
			OFF	when no alarm has occurred since the last clearing of alarm(s)

Valid for outputs:	11, 12, AL0 – AL2
Required settings:	C33

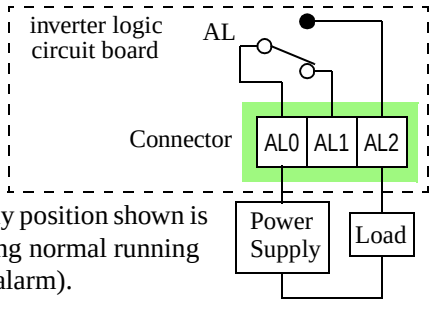
Notes:

- When the alarm output is set to normally closed, a time delay occurs until the contact is closed when the power is turned on. Therefore, when the alarm contact output is to be used, set a delay of about 2 seconds when the power is turned on.
- Terminals 11 and 12 are open collector outputs, so the electric specification of [AL] is different from the contact output terminals AL0, AL1, AL2.
- The logic sequence of terminals 11 and 12 is the same as AL0-AL2.
- See the description of AL1, AL2, and AL0.
- When the inverter power supply is turned off, the alarm signal output is valid as long as the external control circuit has power.
- This signal output has the delay time (300ms nominal) from the fault alarm output.

Example for terminal 11 or 12:



Example for terminals AL0, AL1, AL2:

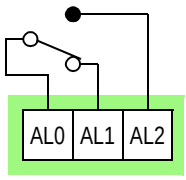
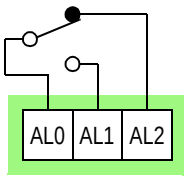
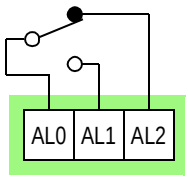
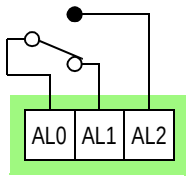


Relay position shown is during normal running (no alarm).

See I/O specs on page 4–5.

NOTE: The relay contact specifications are in the connector input/output specifications on page 4–5. The contact diagrams for different conditions are on the next page.

The alarm output terminals are connected as shown below (left) by default, or after initialization. The contact logic can be inverted as shown (below right) by using the parameter setting C33. The relay contacts normally open (N.O.) and normally closed (N.O.) convention uses “normal” to mean the inverter has power and is in Run or Stop Mode. The relay contacts switch to the opposite position when it is in Trip Mode or when input power is Off.

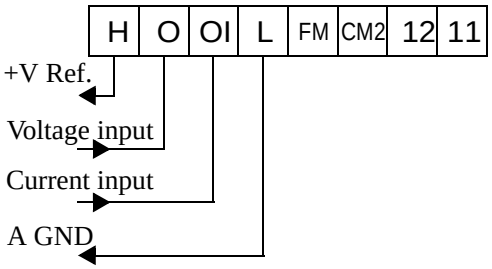
N.C. contacts (after initialization)		**N.O. contact (inverted by C33 setting)**	
During normal running	When an alarm occurs or power is turned off	During normal running or power is turned off	When an alarm occurs
			

Contact	Power	Run State	AL0-AL1	AL0-AL2
N.C. (after initialize, C33=01)	ON	Normal	Closed	Open
	ON	Trip	Open	Closed
	OFF	–	Open	Closed

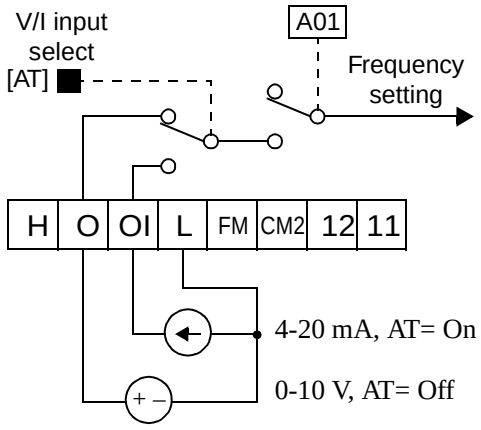
Contact	Power	Run State	AL0-AL1	AL0-AL2
N.O. (set C33=00)	ON	Normal	Open	Closed
	ON	Trip	Closed	Open
	OFF	–	Open	Closed

Analog Input Operation

The L100 inverters provide for analog input to command the inverter frequency output value. The analog input terminal group includes the L, OI, O, and H terminals on the control connector, which provide for Voltage [O] or Current [OI] input. All analog input signals must use the analog ground [L].

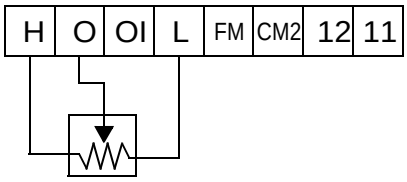


If you use either the voltage or current analog input, you must select one of them using the logic input terminal function [AT] analog type. If terminal [AT] is Off, the voltage input [O] can command the inverter output frequency. If terminal [AT] is On, the current input [OI] can command the inverter output frequency. The [AT] terminal function is covered in the logic input section on page 4–15. Remember that you must also set A01 = 01 to select analog input as the frequency source.



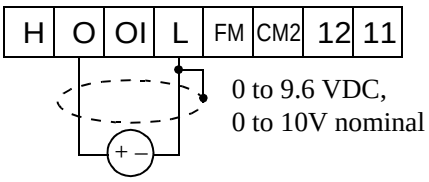
NOTE: If no logic input terminal is configured for the [AT] function, then inverter sums the voltage and current input to determine the desired input value.

Using an external potentiometer is a popular way to control the inverter output frequency (and a good way to learn how to use the analog inputs). The potentiometer uses the 10V reference [H] and the analog ground [L] for excitation, and the voltage input for the signal. By default, the [AT] terminal selects the voltage input when it is Off. Take care to use the proper resistance for the potentiometer, which is 1 to 2 k Ohms, 2 Watts.

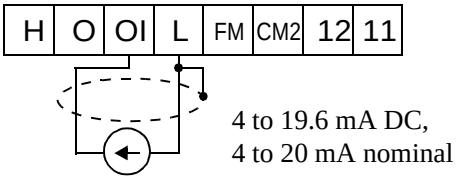


1 to 2 k Ohms, 2 Watts

Voltage Input – The voltage input circuit uses terminals [L] and [O]. Attach the cable shield wire only to terminal [L] on the inverter. Maintain the voltage within specifications (do not apply negative voltage).



Current Input – The current input circuit uses terminals [OI] and [L]. The current come from a *sourcing* type transmitter; a *sinking* type will not work! This means the current must flow into terminal [OI], and terminal [L] is the return back to the transmitter. The input impedance from [OI] to [L] is 250 Ohms. Attach the cable shield wire only to terminal [L] on the inverter.

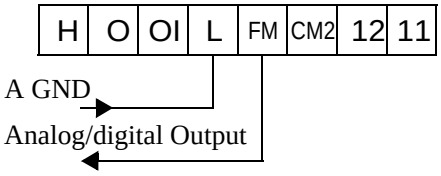


See I/O specs on page 4–5.

Analog and Digital Monitor Output

In the system design for the inverter application, it is useful to monitor the inverter operation from a remote location. In some cases, this is only a panel-mounted analog meter (moving-coil type). In other cases, a controller device such as a PLC may command the inverter frequency and other functions. Sometimes it is useful to have the inverter transmit the (real-time) output frequency value back to the controller to confirm actual operation. The analog output function serves these purposes.

The inverter provides an analog/digital output terminal primarily for frequency monitoring on terminal [FM] (frequency monitor). It uses terminal [L] as analog GND reference. If needed, you can configure terminal [FM] to transmit the inverter current output value instead.

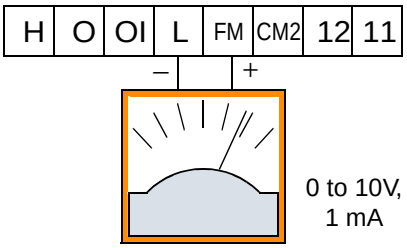


See I/O specs on page 4–5.

Parameter C23 selects the output signal data and transmission format. The selections are:

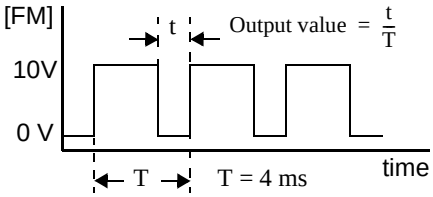
- C23 = 00 Analog monitor output frequency, pulse-width modulated (PWM) format
- C23 = 01 Analog monitor output current, pulse-width modulated (PWM) format
- C23 = 02 Digital monitor output frequency, frequency-modulated format

The analog PWM signals are primarily designed for driving a moving-coil meter. The pulse-width modulated signal is automatically averaged by the inertia of the moving-coil mechanism. The meter's indicator needle mechanically converts the PWM signal to an analog representation. Be sure to use a 10V full-scale DC voltmeter.



The signal characteristics of [FM] for each of the output formats are shown below:

Pulse-width modulation (analog)



C23 = 00 Inverter output frequency
C23 = 01 Inverter output current
B81 PWM scale factor

Frequency Monitor, PWM Signal – (C23 = 00) The [FM] output duty cycle varies with the inverter output frequency. The signal period T is fixed at 4 ms, and the amplitude is fixed at 10 VDC. The signal on [FM] reaches full scale when the inverter outputs the maximum frequency. You can scale the duty cycle with a scale factor setting with parameter B81. This is a dedicated indicator, so that it cannot be used as a line speed signal.

NOTE: The indicator accuracy after adjustment is about ±5%. Depending on the motor, the accuracy may exceed this value.

Current Monitor, PWM Signal – (C23 = 01) – The [FM] output duty cycle varies with the inverter output current to the motor. The signal period T is fixed at 4 ms, and the amplitude is fixed at 10 VDC. The signal on [FM] reaches full scale when the inverter output current reaches 200% of the rated inverter current. You can scale the duty cycle by a scale factor setting with parameter B81. The accuracy of the current reading is given by the equation:

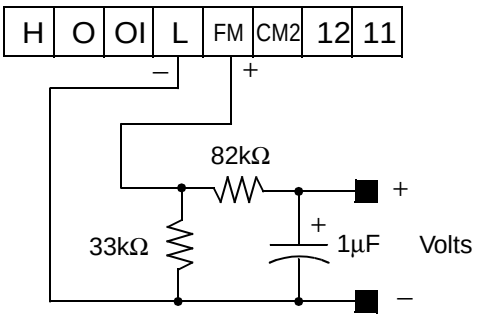
$$\frac{Imc - Im}{Ir} \times 100 \leq \pm 20\%$$

Im = Inverter output current (measured)
Imc = Monitor display current
Ir = Inverter rated current

NOTE: The monitor display accuracy (normally ± 20%, depending on the connected motor's characteristics) can be improved by the adjustment of parameter B32. If precise current measurement is necessary, use the moving-coil type ammeter between the inverter and the motor.

TIP: When using the analog meter for monitoring, adjust the meter so it has a zero reading when the [FM] output is zero. Then use scale factor B81 to adjust the [FM] output so the maximum frequency in the inverter corresponds to a full-scale reading on the meter.

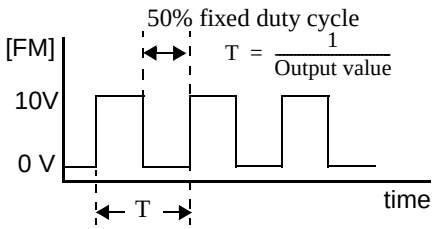
PWM Smoothing Circuit – You may need to smooth the PWM signal, converting it to a relatively stable DC analog voltage which represents the [FM] output value. To do this, use the circuit shown to the right. Note the output impedance of the circuit is at least 82k Ohms, so the monitoring device needs an input impedance of 1 Meg. Ohms or greater. Otherwise, the impedance of the smoothing circuit will cause a non-linearity in the reading.



See I/O specs on page 4–5.

Frequency Monitor, FM Signal – (C23 = 02) – The [FM] output frequency varies with the inverter output frequency. The maximum frequency of [FM] is 3.6 kHz, or 10 times the inverter maximum frequency. The signal on [FM] reaches the maximum frequency when the inverter outputs the maximum frequency. You can scale its relationship to the inverter output with the scale factor setting with parameter B86.

Frequency modulation (digital)

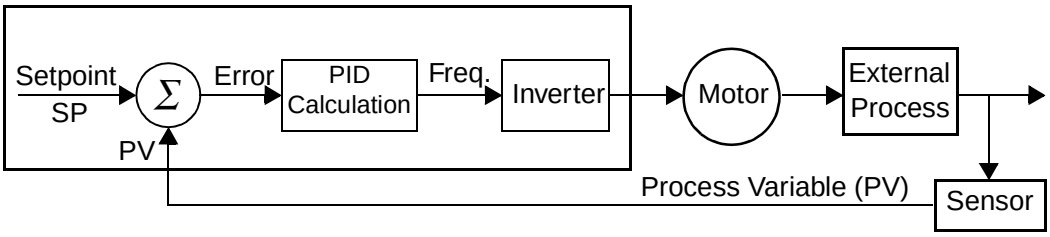


C23 = 02 Inverter output frequency
B86 Freq. scale factor

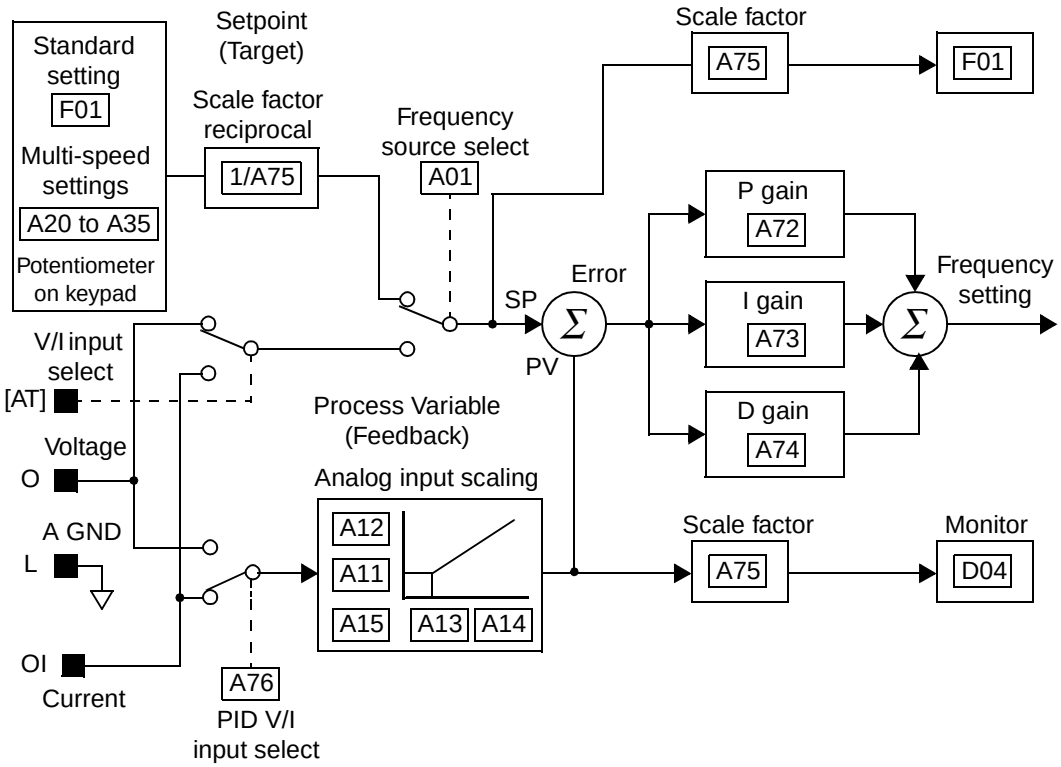
PID Loop Operation

In standard operation, the inverter uses a reference source selected by parameter A01 for the output frequency, which may be a fixed value (F01), a variable set by the front panel potentiometer, or value from an analog input (voltage or current). To enable PID operation, set A71 = 01. This causes the inverter to *calculate* the target frequency, or setpoint.

A calculated target frequency can have a lot of advantages. It lets the inverter adjust the motor speed to optimize some other process of interest, while saving energy as well. Refer to the figure below. The motor has some eventual effect on a process of interest. To control the external process, the inverter must monitor the process variable. This requires wiring a sensor to either the analog input terminal O (voltage) or terminal OI (current).



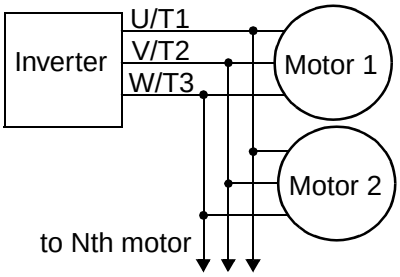
When enabled, the PID loop calculates the ideal output frequency to minimize the loop error. This means we no longer command the inverter to run at a particular frequency, but we specify the ideal value for the process variable. That ideal value is called the *setpoint*, and is specified in the units of the external process variable. For a pump application it may be gallons/minute, or it could be air velocity or temperature for an HVAC unit. Parameter A75 is a scale factor that relates the external process variable units to motor frequency. The figure below is a more detailed diagram of the PID function.



Configuring the Inverter for Multiple Motors

Simultaneous Connections

For some applications, you may need to connect two or more motors (wired in parallel) to a single inverter's output. For example, this is common in conveyor applications where two separate conveyors need to have approximately the same speed. The use of two motors may be less expensive than making the mechanical link for one motor to drive multiple conveyors.



Some of the characteristics of using multiple motors with one drive are:

- The inverter output must be rated to handle the sum of the currents from the motors.
- You must use separate thermal protection switches or devices to protect each motor. Locate the device for each motor inside the motor housing or as close to it as possible.
- The wiring for the motors must be permanently connected in parallel (do not remove one motor from the circuit during operation).

NOTE: The motor speeds are identical only in theory. That is because slight differences in their loads will cause one motor to slip a little more than another, even if the motors are identical. Therefore, do not use this technique for multi-axis machinery that must maintain a fixed position reference between its axes.

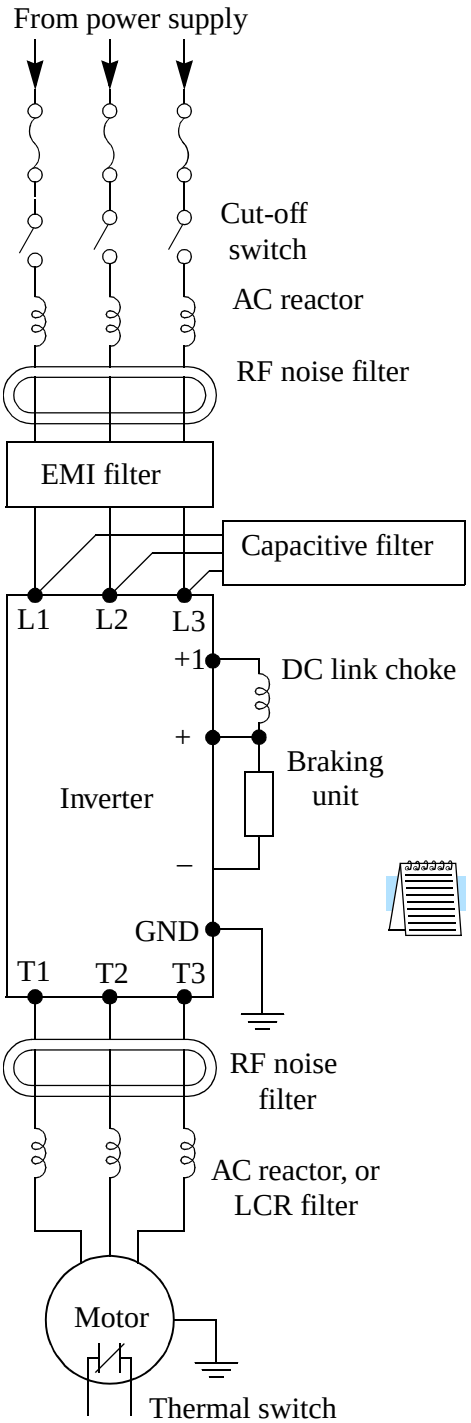
Motor Control Accessories

5

In This Chapter.... page

Introduction

A motor control system will obviously include a motor and inverter, as well as fuses for safety. If you are connecting a motor to the inverter on a test bench just to get started, that's all you may need for now. But a fully developed system can also have a variety of additional components. Some can be for noise suppression, while others may enhance the inverter's braking performance. The figure below shows a system with several possible optional components, and the table gives part number information.



Name	Part No. Series		See page
	Europe, Japan	USA	
AC reactor, input side	ALI–xxx	HRL–x	3
RF noise filter, input side	ZCL–x	ZCL–x	4
EMI filter (for CE)	FFL100–xx	FFL100–xx	4
Capacitive filter	CFI–x	CFI–x	4
DC link choke	—	HDC–xxx	4
Resistance braking unit	BRD–xxx	BRD–xxx	5
RF noise filter, output side	ZCL–xxx	ZCL–xxx	4
AC reactor, output side	ALI–xxx	HRL–xxx	3
LCR filter	—	HRL–xxC	3

NOTE: The Hitachi part number series for accessories includes different sizes of each part type, specified by the –x suffix. Hitachi product literature can help match size and rating of the your inverter to the proper accessory size.

Each inverter accessory comes with its own printed instruction manual. Please refer to those manuals for complete installation details. This chapter gives only an overview of these optional system devices.

Component Descriptions

AC Reactors, Input Side

This is useful in suppressing harmonics induced on the power supply lines, or when the main power voltage imbalance exceeds 3% (and power source capacity is more than 500 kVA), or to smooth out line fluctuations. It also improves the power factor.

In the following cases for a general-purpose inverter, a large peak current flows on the main power supply side, and is able to destroy the inverter module:

- If the unbalanced factor of the power supply is 3% or higher
- If the power supply capacity is at least 10 times greater than the inverter capacity (the power supply capacity is 500 kVA or more)
- If abrupt power supply changes are expected

Examples of these situations include:

1. Several inverters are interconnected (input side) with a short bus.

2. A thyristor converter and an inverter are interconnected (input side) with a short bus.

3. An installed phase advance capacitor opens and closes.

Where these conditions exist or when the connected equipment must be highly reliable, install an AC reactor between the power supply and the inverter. Also, where the effects of an indirect lightning strike is possible, install a lightning conductor.

Example calculation:

V_{RS} = 205V, V_{ST} = 203V, V_{TR} = 197V,
where V_{RS} is R-S line voltage, V_{ST} is S-T line voltage, V_{TR} is T-R line voltage

$$\text{Unbalance factor of voltage} = \frac{\text{Max. line voltage (min.)} - \text{Mean line voltage}}{\text{Meanline voltage}} \times 100$$

$$= \frac{V_{RS} - (V_{RS} + V_{ST} + V_{TR})/3}{(V_{RS} + V_{ST} + V_{TR})/3} \times 100 = \frac{205 - 202}{202} \times 100 = 1.5\%$$

Please refer to the documentation that comes with the RF noise filter for installation instructions.

AC Reactors, Output Side

This reactor reduces the vibrations in the motor caused by the inverter's switching waveforms, by smoothing the waveforms to approximate commercial power quality. It is also useful when wiring from the inverter to the motor is more than 10m in length, to reduce reflected voltage wave phenomenon. Please refer to the documentation that comes with the RF noise filter for installation instructions.

RF Noise Filters (Magnetic Choke)

Electrical noise interference may occur on nearby equipment such as a radio receiver. This magnetic choke filter helps reduce radiated noise from the inverter wiring. It can be used on the input or output side of the inverter. The example magnetic choke shown to the right comes with a mounting bracket. The wiring must go through the opening to reduce the RF component of the electrical noise. Loop the wires three times (four turns) to attain the full RF filtering effect.

ZCL–x

EMI Filter

The EMI filter reduces the conducted noise on the power supply wiring generated by the main power supply, protecting the inverter. Connect the EMI filter to the inverter primary (input side). The FFL100 series filter is required for compliance to the EMC directive (Europe) and C-TICK (Australia). The other filters are not for this purpose.

WARNING: The EMI filter has high internal leakage current from power wiring to the chassis. Therefore, connect the chassis ground of the EMI filter before making the power connections to avoid danger of shock or injury.

EMI–x

RF Noise Filter (Capacitive)

This capacitive filter reduces radiated noise from the main power wires in the inverter input side. This filter is not for achieving CE compliance and is applicable to the input side only of the inverter. It comes in two versions — for 200V class inverters or 400V class inverters. Please refer to the documentation that comes with the radio noise filter for installation instructions.

DC Link Choke

The DC choke (reactor) suppresses harmonics generated by the inverter. It attenuates the high-frequency components on the inverter's internal DC bus (link). However, note that it does not protect the diode rectifiers in the inverter input circuit.

Dynamic Braking

The purpose of dynamic braking is to improve the ability of the inverter to stop (decelerate) the motor and load. This becomes necessary when an application has some or all of the following factors:

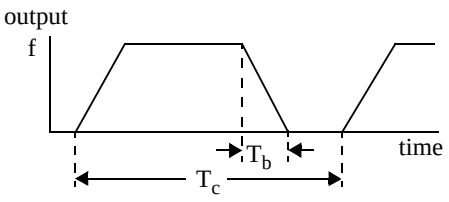
- High load inertia compared to the available motor torque
- The application requires frequent or sudden changes in speed
- System losses are not great enough to slow the motor as needed

When the inverter slows its output frequency to decelerate the load, the motor can temporarily become a generator. This occurs when the motor rotation develops a voltage higher than the inverter internal (DC) bus voltage. This condition can cause the inverter to have an over-voltage fault and enter the Trip Mode. In many applications, the over-voltage condition serves as a warning signal that we have exceeded the deceleration capabilities of the system. The L100 inverter can connect to an external braking unit, which accepts the excess energy from the motor during deceleration to its internal resistor(s). The power resistor serves as a generator load, developing heat to stop the motor just as brakes on an automobile develop heat during braking. You can also add an external resistor to the braking unit for additional braking torque.

A switching circuit and power resistor are the main components of the dynamic braking unit, which includes a fuse and thermally activated alarm relay for safety. However, be careful to avoid overheating its resistor. The fuse and thermal relay are safeguards for extreme conditions, but the inverter can maintain braking usage in a safe zone. The following table specifies the braking options for 200V class L100 inverters and the braking torque for each option. Use BRD–E2 braking unit for 200V class inverters.

L100 Inverter 200V Models			BRD–E2 Braking Unit							
Model Number	HP	Braking torque without braking unit	Using built-in resistor only		External resistor added					
					HRB1		HRB2		HRB3	
			A	B	A	B	A	B	A	B
002NFE/NFU	1/4	50%	150%	120%	Over-range		Over-range		Over-range	
004/005NFE/NFU	1/2	50%	150%	120%	Over-range		Over-range		Over-range	
007NFE/NFU	1	50%	100%	80%	150%	120%	Over-range		Over-range	
011/015NFE/NFU	2	50%	60%	60%	100%	80%	150%	120%	Over-range	
022NFE/NFU	3	20%	50%	50%	100%	80%	120%	100%	Over-range	
037LFU	5	20%	40%	40%	60%	60%	80%	80%	150%	120%
055LFU	7.5	20%	30%	30%	50%	50%	60%	60%	100%	80%
075LFU	10	20%	—	—	40%	40%	60%	60%	80%	80%

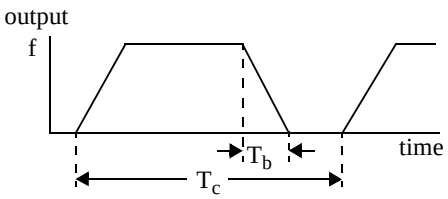
Note 1: A = Average braking torque from 60 Hz to 3 Hz.
Note 2: B = Average braking torque from 120 Hz to 3 Hz.
Note 3: BRD maximum duty cycle = 10%, where $T_b/T_c \leq 0.1$ sec.
Note 4: BRD maximum continuous On time $T_b \leq 10$ sec.



The following table specifies the braking options for 400V class L100 inverters and the braking torque for each option. Use BRD–EZ2 braking unit for 400V class inverters.

L100 Inverter 400V Models			BRD–EZ2 Braking Unit							
Model Number	HP	Braking torque without braking unit	Using built-in resistor only		External resistor added					
					HRB1		HRB2		HRB3	
			A	B	A	B	A	B	A	B
004HFE/HFU	1/2	50%	150%	120%	Over-range		Over-range		Over-range	
007HFE/HFU	1	50%	100%	80%	150%	120%	Over-range		Over-range	
015HFE/HFU	2	50%	60%	60%	100%	80%	150%	120%	Over-range	
022HFE/HFU	3	20%	50%	50%	100%	80%	150%	120%	Over-range	
030/040HFE/HFU	5	20%	40%	40%	60%	60%	120%	100%	150%	120%
055HFE/HFU	7.5	20%	30%	30%	50%	50%	80%	60%	100%	80%
075HFE/HFU	10	20%	—	—	40%	40%	60%	60%	80%	80%

Note 1: A = Average braking torque from 60 Hz to 3 Hz.
Note 2: B = Average braking torque from 120 Hz to 3 Hz.
Note 3: BRD maximum duty cycle = 10%, where $T_b/T_c \leq 0.1$ sec.
Note 4: BRD maximum continuous On time $T_b \leq 10$ sec.



Troubleshooting and Maintenance

6

In This Chapter.... page

Troubleshooting

Safety Messages

Please read the following safety messages before troubleshooting or performing maintenance on the inverter and motor system.

WARNING: Wait at least five (5) minutes after turning off the input power supply before performing maintenance or an inspection. Otherwise, there is the danger of electric shock.

WARNING: Make sure that only qualified personnel will perform maintenance, inspection, and part replacement. (Before starting to work, remove any metallic objects from your person (wristwatch, bracelet, etc.). Be sure to use tools with insulated handles. Otherwise, there is a danger of electric shock and/or injury to personnel.

WARNING: Never remove connectors by pulling on its wire leads (wires for cooling fan and logic p.c.board). Otherwise, there is a danger of fire or injury due to wire breakage.

CAUTION: When removing connectors, never pull the wires (wires for the cooling fan and logic P.C. board. Otherwise, there is danger of fire due to wire breakage and/or injury to personnel.

General Precautions and Notes

- Always keep the unit clean so that dust or other foreign matter does not enter the inverter.
- Take special care in regard to breaking wires or making connection mistakes.
- Firmly connect terminals and connectors.
- Keep electronic equipment away from moisture and oil. Dust, steel filings and other foreign matter can damage insulation, causing unexpected accidents, so take special care.

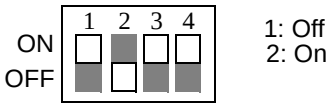
Inspection Items

This chapter provides instructions or checklists for these inspection items:

- Daily inspection
- Periodic inspection (approximately once a year)
- Insulation resistance test

Troubleshooting Tips

The table below lists typical symptoms and the corresponding solution(s).

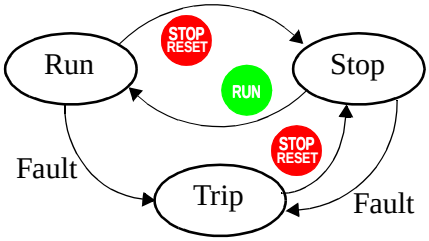
Symptom/condition		Probable Cause	Solution
The motor will not run.	The inverter outputs U, V, W are not supplying voltage.	• Is the frequency command source A01 parameter setting correct? • Is the Run command source A02 parameter setting correct?	• Make sure the parameter setting A01 is correct. • Make sure the parameter setting A02 is correct.
		• Is power being supplied to terminals L1, L2, and L3(N)? If so, the POWER lamp should be on.	• Check terminals L1, L2, and L3(N), then U/T1, V/T2, and W/T3. • Turn on the power supply or check fuses.
		• Is there an error code EXX displayed?	• Press the Func. key and determine the error type. Then clear the error (Reset).
		• Are the signals to the intelligent input terminals correct? • Is the Run Command active? • Is the [FW] terminal (or [RV]) connected to P24 (via switch, etc.)	• Verify the terminal functions for C01 - C05 are correct. • Turn on Run Command. • Supply 24V to [FW] or [RV] terminal, if configured.
		• Has the frequency setting for F01 been set greater than zero? • Are the control circuit terminals H, O, and L connected to the potentiometer?	• Set the parameter for F01 to a safe, non-zero value. • If the potentiometer is the frequency setting source, verify voltage at “O” > 0V.
		• Is the RS (reset) function or FRS (free-run stop) function on?	• Turn off the command(s).
	Inverter outputs U, V, W are supplying voltage.	• Is the motor load too heavy?	• Reduce load, and test the motor independently.
	The optional remote operator is used (DR/W)	• Are the operational settings between the remote operator and the inverter unit correct?	• Check switches 1 and 2 on the optional remote operator (copy unit). 
The direction of the motor is reversed.		• Are the connections of output terminals U/T1, V/T2, and W/T3 correct? • Is the phase sequence of the motor forward or reverse with respect to U/T1,V/T2, and W/T3?	• Make connections according to the phase sequence of the motor. In general: FWD = U-V-W, and REV=U-W-V.
		• Are the control terminals [FW] and [RV] wired correctly? • Is parameter F04 properly set?	• Use terminal [FW] for forward, and [RV] is reverse. • Set motor direction in F04.

Symptom/condition		Probable Cause	Solution
The motor speed will not reach the target frequency (desired speed).		• If using the analog input, is the current or voltage at “O” or “OI?”	• Check the wiring. • Check the potentiometer or signal generating device.
		• Is the load too heavy?	• Reduce the load. • Heavy loads activate the overload restriction feature (reduces output as needed).
The rotation is unstable.		• Is the load fluctuation too great? • Is the supply voltage unstable? • Is the problem occurring at a particular frequency?	• Increase the motor capacity (both inverter and motor). • Fix power supply problem. • Change the output frequency slightly, or use the jump frequency setting to skip the problem frequency.
The RPM of the motor does not match the inverter output frequency setting.		• Is the maximum frequency setting A04 correct? • Does the monitor function D01 display the expected output frequency?	• Verify the V/F settings match motor specifications. • Make sure all scaling (such as A11 to A14) is properly set.
Inverter data is not correct.	No downloads have occurred.	• Was power turned off after a parameter edit but before pressing the Store key?	• Edit the data and press the Store key once.
		• Edits to data are permanently stored at power down. Was the time from power Off to power On less than six seconds?	• Wait six seconds or more before turning power Off after editing data.
	A download to the inverter was attempted.	• Was the power turned off within six seconds after the display changed from REMT to INV?	• Copy the data to the inverter again, and keep power on for six seconds or more after copying.
A parameter will not change after an edit (reverts to old setting).	True for certain parameters	• Is the inverter in Run Mode? Some parameters cannot be edited during Run Mode.	• Put inverter in Stop Mode (press the Stop/reset key). Then edit the parameter.
	True for all parameters	• If you’re using the [SFT] intelligent input (software lock function), — is the [SFT] input on? • Is switch 4 (located on the back of the remote operator copy unit) On?	• Change the state of the SFT input, and check the B31 parameter (SFT mode). • Turn the switch off.

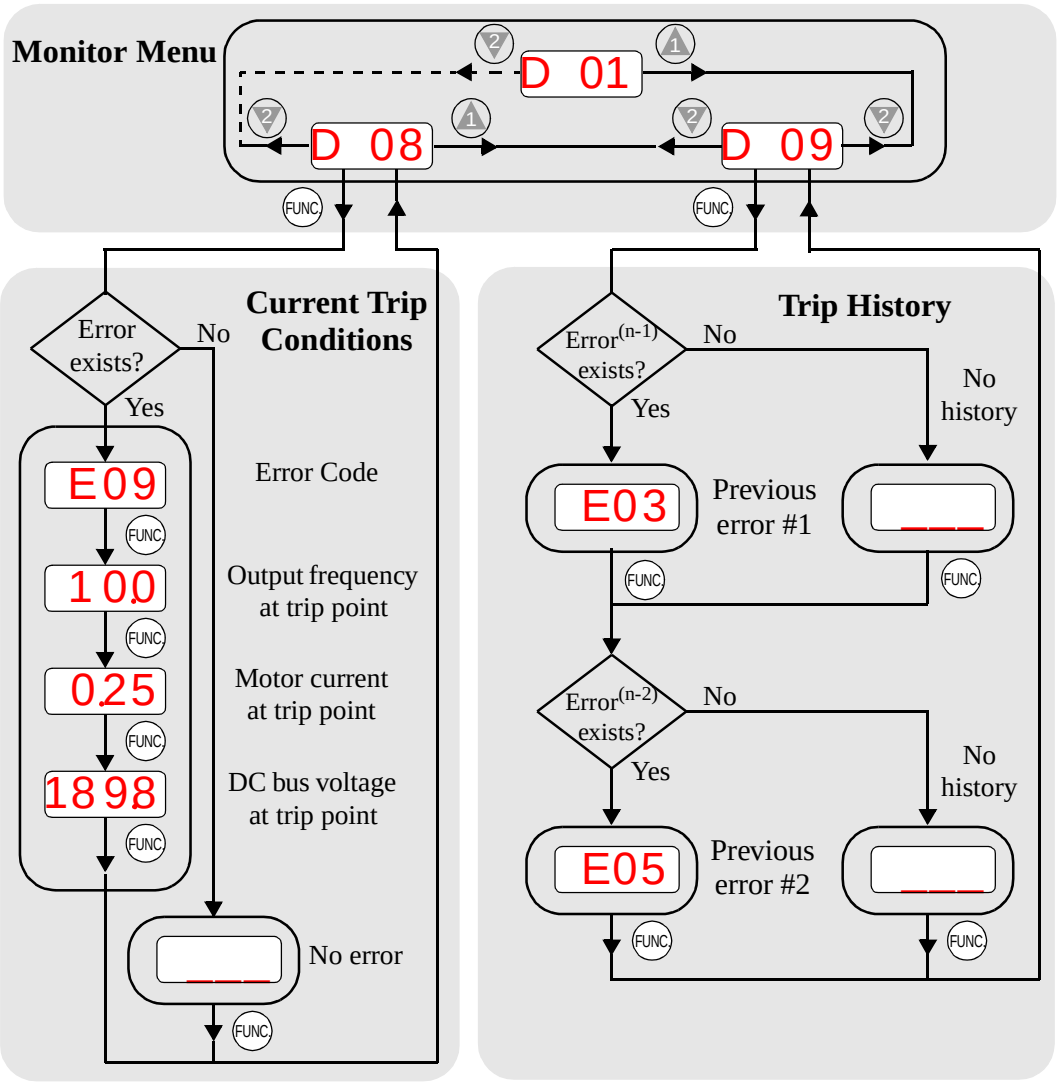
Monitoring Trip Events, History, & Conditions

Inverter Fault Detection

The microprocessor in the inverter detects a variety of fault conditions and latches the event, recording it in a history table. The inverter output turns off, or "trips" similar to the way a circuit breaker trips due to an over-current condition. Most faults occur when the motor is running (refer to the diagram to the right). However, the inverter could have an internal fault and trip in Stop Mode. In either case, you can clear the fault by pressing the Stop/Reset key.



We recommend that you first find the cause of the fault before clearing it. When a fault occurs, the inverter stores important performance data at the moment of the fault. To access the data, use the monitor functions (Dxx) and select D08 for details about the present fault (E^n), or the error code for the past two trip events (E^{n-1} and E^{n-2}) using the D09 Trip History function. A listing of error codes is on the next page.



Error Codes

An error code will appear on the display automatically when a fault causes the inverter to trip. The following table lists the cause associated with the error.

Error Code	Name	Cause(s)
E01	Over current event while at constant speed	The inverter output was short-circuited, or the motor shaft is locked or has a heavy load. These conditions cause excessive current for the inverter, so the inverter output is turned off.
E02	Over current event during deceleration	
E03	Over current event during acceleration	
E04	Over current event while motor is stopped	
E05	Overload protection	When a motor overload is detected by the electronic thermal function, the inverter trips and turns off its output.
E07	Over voltage protection	When the DC bus voltage exceeds a threshold, due to regenerative energy from the motor.
E08	EEPROM error	When the built-in EEPROM memory has problems due to noise or excessive temperature, the inverter trips and turns off its output to the motor.
E09	Under-voltage error	A decrease of internal DC bus voltage below a threshold results in a control circuit fault. This condition can also generate excessive motor heat or cause low torque. The inverter trips and turns off its output.
E11 E22	CPU error	A malfunction in the built-in CPU has occurred, so the inverter trips and turns off its output to the motor.
E12	External trip	A signal on an intelligent input terminal configured as EXT has occurred. The inverter trips and turns off the output to the motor.
E13	USP	When the Unattended Start Protection (USP) is enabled, an error occurred when power is cycled while the inverter is in Run Mode. The inverter trips and does not go into Run Mode until the error is cleared.
E14	Ground fault	The inverter is protected by the detection of ground faults between the inverter output and the motor upon during powerup tests. This feature protects the inverter, and does not protect humans.
E15	Input over-voltage	When the input voltage is higher than the specified value, it is detected 100 seconds after powerup and the inverter trips and turns off its output.
E21	Inverter thermal trip	When the inverter internal temperature is higher than the specified value, the thermal sensor in the inverter module detects the higher temperature of the power devices and trips, turning the inverter output off.

Error Code	Name	Cause(s)
E35	PTC error	When intelligent terminal 5 is configured for PTC (protective thermistor) function and the inverter has sensed the resistance is too high (wire is broken or temperature is too high), the inverter trips and turns off the output.

NOTE: If an EEPROM error (E08) occurs, be sure to confirm the parameter data values are still correct. If the power is turned off while the [RS] (Reset) intelligent input terminal is On, an EEPROM error will occur when power is restored.

Restoring Factory Default Settings

You can restore all inverter parameters to the original factory (default) settings, for the intended country of use. After initializing the inverter, use the powerup test in Chapter 2 to get the motor running again. To initialize the inverter, follow the steps below.

1. First, check the value of function code B85. The initialization in step 2 will restore defaults for the country code programmed in function B85:
00 = Japan (do not set), 01 = Europe, 02 = United States

Please do not change this setting unless you are absolutely sure the power input voltage range and frequency match the country code setting.

2. Initialization - this uses function code B84. Follow the steps in the table below.

Action	Display	Func./Parameter
Press the FUNC key.	D 01	First "D" group parameter
Press the ▼ key twice.	B - -	"B" group selected
Press the FUNC key.	B 01	First "B" parameter selected
Press and hold the ▲ key until ->	B 84	Initialization function selected
Press the FUNC key.	00	0 = initialization disabled
Press the ▲ key.	01	1 = initialization enabled
Press the STR key.	B 84	Initialization now enabled to restore all defaults
Press and hold the FUNC, ▲, and ▼ keys. Do not let release yet.	B 84	First part of special key sequence
Holding the keys above, press and hold the STOP RESET (STOP) key for 3 sec.	B 84	Final part of special key sequence
Release only the STOP RESET (STOP) key, and wait for the display d 01 to appear and begin blinking.	D 01	Initialization begins when display starts blinking
Now release the FUNC, ▲, and ▼ keys only after the d 01 display function begins blinking.	EU or USA	Default parameter country code shown during initialization process (left-most char displays alternating pattern)
Initialization is complete.	D 01	Function code for output frequency monitor shown

NOTE: Initialization cannot be performed with a remote operator panel. Disconnect the device and use the inverter's front panel keypad.

Maintenance and Inspection

Monthly and Yearly Inspection Chart

Item Inspected		Check for...	Inspection Cycle		Inspection Method	Criteria
			Month	Year		
Overall	Ambient environment	Extreme temperatures & humidity	✔		Thermometer, hygrometer	Ambient temperature between -10 to 40°C, non-condensing
	Major devices	Abnormal vibration, noise	✔		Visual and aural	Stable environment for electronic controls
	Power supply voltage	Voltage tolerance	✔		Digital volt meter, measure between inverter terminals L1, L2, L3	200V class: 200 to 240V 50/60 Hz 400V class: 380 to 460V 50/60 Hz
Main circuit	Ground Insulation	Adequate resistance		✔	Digital volt meter, GND to terminals	5 Meg. Ohms or greater
	Mounting	No loose screws		✔	Torque wrench	M3: 0.5 – 0.6 Nm M4: 0.98 – 1.3 Nm M5: 1.5 – 2.0 Nm
	Components	Overheating		✔	Thermal trip events	No trip events
	Housing	Dirt, dust		✔	Visual	Vacuum dust and dirt
	Terminal block	Secure connections		✔	Visual	No abnormalities
	Smoothing capacitor	Leaking, swelling	✔		Visual	No abnormalities
	Relay(s)	Chattering		✔	Aural	Single click when switching On or Off
	Resistors	Cracks or discoloring		✔	Visual	Use Ohm meter to check braking resistors
	Cooling fan	Noise	✔		Power down, manually rotate	Rotation must be smooth
		Dust	✔		Visual	Vacuum to clean
Control circuit	Overall	No odor, discoloring, corrosion		✔	Visual	No abnormalities
	Capacitor	No leaks or deformation	✔		Visual	Undistorted appearance
Display	LEDs	Legibility	✔		Visual	All LED segments work

Note 1: The life of a capacitor is affected by the ambient temperature. See the Capacitor Life Curve on the next page.

Note 2: The inverter must be cleaned periodically. If dust accumulates on the fan and heat sink, it can cause overheating of the inverter.

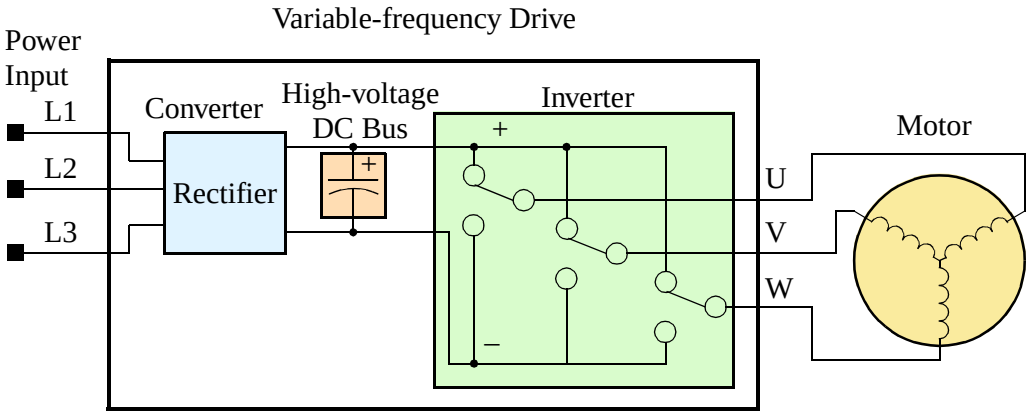
Spare parts

We recommend that you stock spare parts to reduce down time, which include:

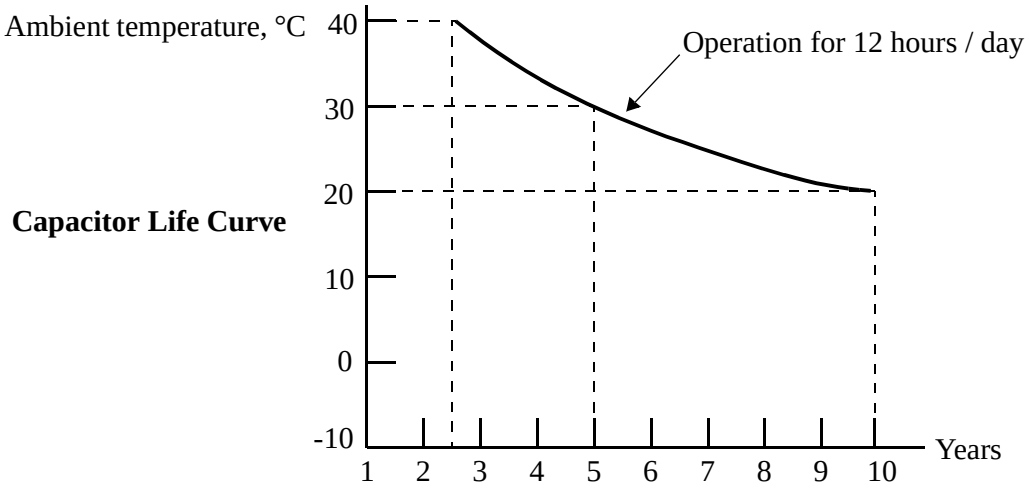
Part description	Symbol	Quantity		Notes
		Used	Spare	
Cooling fan	FAN	1	1	022NF, 037LF, 015HF to 075HF
Case	CV	1	1	Front case Key cover Case Bottom cover

Capacitor Life Curve

The DC bus inside the inverter uses a large capacitor as shown in the diagram below. The capacitor handles high voltage and current as it smooths the power for use by the inverter. So, any degradation of the capacitor will affect the performance of the inverter.



Capacitor life is reduced in higher ambient temperatures, as the graph below demonstrates. Be sure to keep the ambient temperature at acceptable levels, and perform maintenance inspections on the fan, heat sink, and other components. If the inverter is installed on a cabinet, the ambient temperature is the temperature inside the cabinet.



Capacitor Life Curve

General Inverter Electrical Measurements

The following table specifies how to measure key system electrical parameters. The diagrams on the next page show inverter-motor systems and the location of measurement points for these parameters.

Parameter	Circuit location of measurement	Measuring instrument	Notes	Reference Value
Supply voltage E_1	E_R – across L1 and L2 E_S – across L2 and L3 E_T – across L3 and L1	Moving-coil type voltmeter or rectifier type voltmeter	Fundamental wave effective value	Commercial supply voltage (200V class) 200-240V, 50/60 Hz 400V class 380-460V, 50/60 Hz
Supply current I_1	I_r – L1, I_s – L2, I_t – L3		Total effective value	—
Supply power W_1	W_{11} – across L1 and L2 W_{12} – across L2 and L3		Total effective value	—
Supply power factor Pf_1	$Pf_1 = \frac{W_1}{\sqrt{3} \times E_1 \times I_1} \times 100\%$			—
Output voltage E_0	E_U – across U and V E_V – across V and W E_W – across W and U	Rectifier type voltmeter	Total effective value	—
Output current I_o	I_U – U I_V – V I_W – W	Moving-coil ammeter	Total effective value	—
Output power W_o	W_{01} – across U and V W_{02} – across V and W	Electronic type wattmeter	Total effective value	—
Output power factor Pf_o	Calculate the output power factor from the output voltage E, output current I, and output power W. $Pf_0 = \frac{W_0}{\sqrt{3} \times E_0 \times I_0} \times 100\%$			—

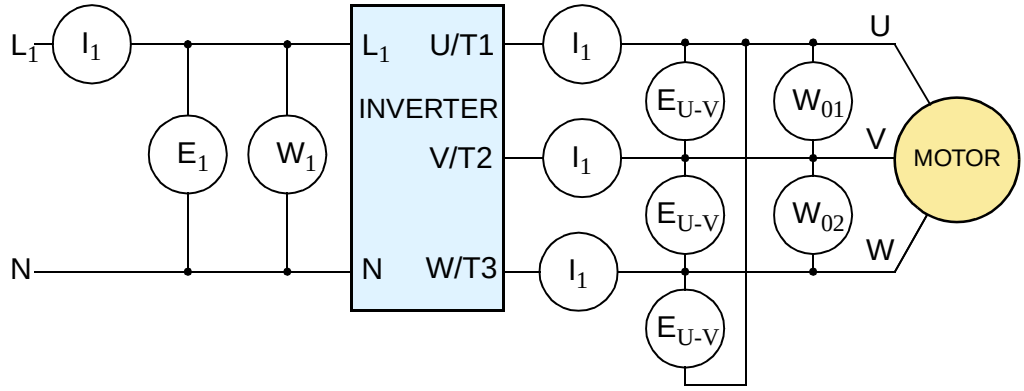
Note 1: Use a meter indicating a fundamental wave effective value for voltage, and meters indicating total effective values for current and power.

Note 2: The inverter output has a distorted waveform, and low frequencies may cause erroneous readings. However, the measuring instruments and methods listed above provide comparably accurate results.

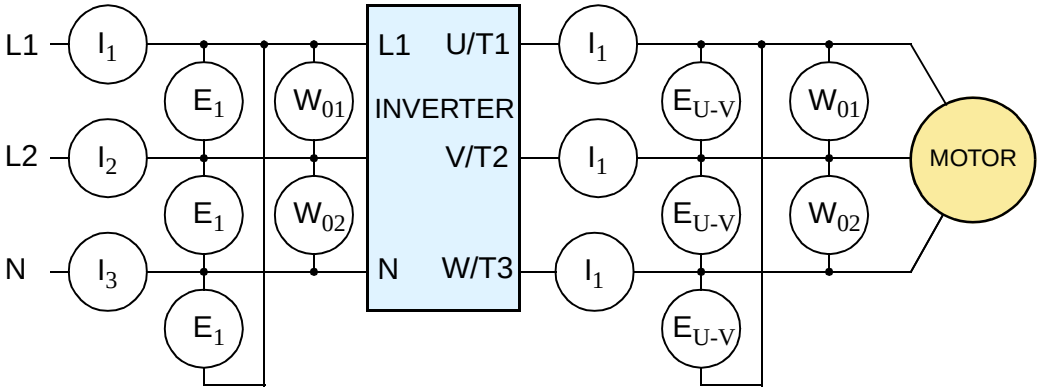
Note 3: A general-purpose digital volt meter (DVM) is not usually suitable to measure a distorted waveform (not pure sinusoid).

The figures below show measurement locations for voltage, current, and power measurements listed in the table on the previous page. The voltage to be measured is the fundamental wave effective voltage. The power to be measured is the total effective power.

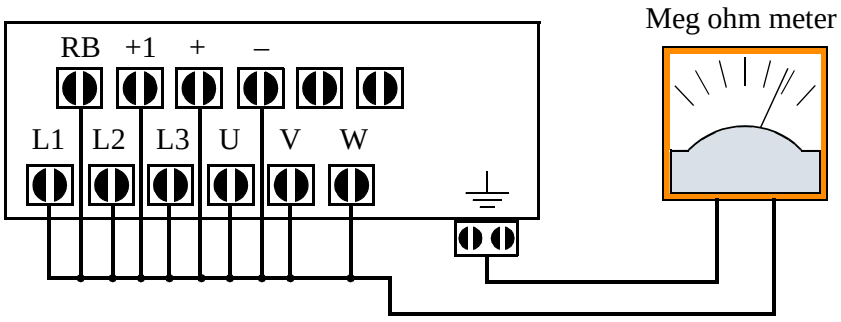
Single-phase measurement diagram



Three-phase measurement diagram



Conduct the insulation resistance test by short circuiting the terminals as shown below.

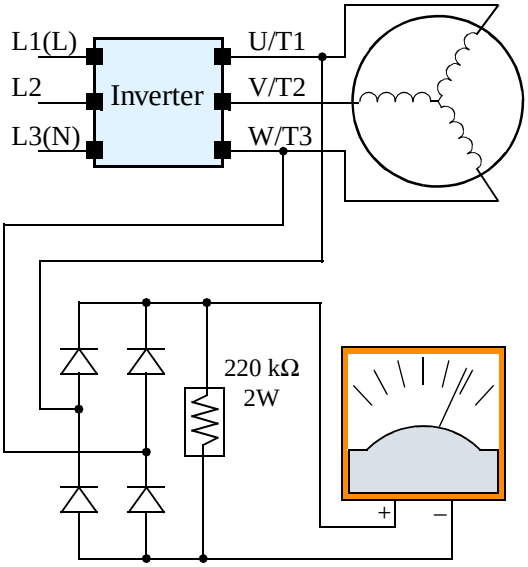


CAUTION: Never test the withstand voltage (HIPOT) on the inverter. The inverter has a surge protector between the main circuit terminals above and the chassis ground.

Inverter Output Voltage Measurement Techniques

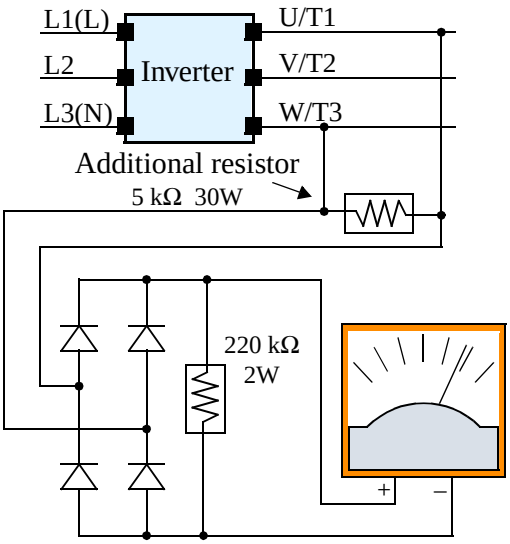
Taking voltage measurements around drives equipment requires the right equipment and a safe approach. You are working with high voltages and high-frequency switching waveforms that are not pure sinusoids. Digital voltmeters will not usually produce reliable readings for these waveforms. And, it is usually risky to connect high voltage signals to oscilloscopes. The inverter output semiconductors have some leakage, and no-load measurements produce misleading results. So, we highly recommend using the following circuits to measure voltage for performing the equipment inspections.

Voltage measurement *with* load



V class	Diode bridge	Voltmeter
200V class	600V 0.01A min.	300V range
400V class	1000V 0.1 A min.	600V range

Voltage measurement *without* load



V class	Diode bridge	Voltmeter
200V class	600V 0.01A min.	300V range
400V class	1000V 0.1 A min.	600V range

HIGH VOLTAGE: Be careful not to touch wiring or connector terminals when working with the inverters and taking measurements. Be sure to place the measurement circuitry above in an insulated housing before using them.

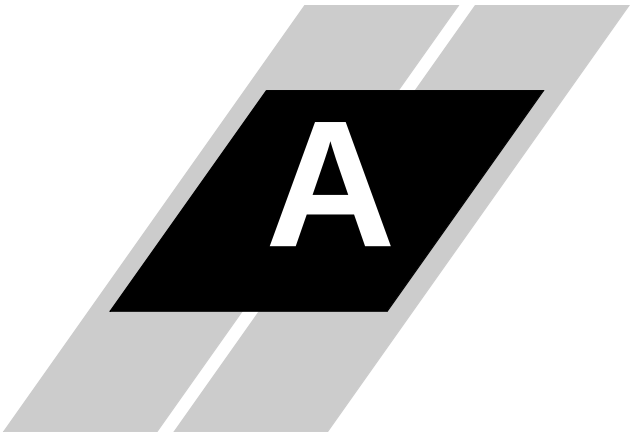
Warranty

Warranty Terms

The warranty period under normal installation and handling conditions shall be one (1) year after the date of installation. The warranty shall cover the repair of only the inverter that was installed.

1. Service in the following cases, even within the warranty period, shall be charged to the purchaser:
   - **a.** Malfunction or damage caused by mis-operation or modification or improper repair
   - **b.** Malfunction or damage caused by a drop after purchase and transportation
   - **c.** Malfunction or damage caused by fire, earthquake, flood, lightening, abnormal input voltage, contamination, or other natural disasters
2. When service is required for the product at your work site, all expenses associated with field repair shall be charged to the purchaser.
3. Always keep this manual handy; please do not loose it. Please contact your Hitachi distributor to purchase replacement or additional manuals.

Glossary and Bibliography



In This Appendix.... page

Glossary

Ambient Temperature The air temperature in the chamber in which a powered electronic unit resides. A unit's heat sinks rely on a lower ambient temperature in order to dissipate heat away from sensitive electronics.

Auto-tuning The ability of a controller to execute a procedure that interacts with a load to determine the proper coefficients to use in the control algorithm. Auto tuning is a common feature of process controllers with PID loops. Hitachi inverters (such as SJ100 series) feature auto-tuning to determine motor parameters for optimal commutation. Auto-tuning is available (for SJ100) as a special command from a digital operator panel. See also *digital operator panel*.

Base Frequency The power input frequency for which an AC induction motor is designed to operate. Most motors will specify a 50 to 60 Hz value. The Hitachi inverters have a programmable base frequency, so you must ensure that parameter matches the attached motor. The term *base frequency* helps differentiate it from the carrier frequency. See also *carrier frequency* and *frequency setting*.

Braking Resistor Some variable speed drives can cause the motor to develop decelerating torque by switching motor wiring so the motor becomes a generator, connected to an energy-absorbing resistor. See also *four-quadrant operation* and *dynamic braking.*

Break-away Torque The torque a motor must produce to overcome the static friction of a load, in order to start the load moving.

Brushes A sliding electrical connection between a fixed post inside the motor housing and a ring on the motor shaft. Typically used in DC motors or low-cost AC motors, brushes route current to windings on the rotor. AC induction motors with a squirrel-cage design do not have the need for brushes. See also *commutation* and *squirrel cage*.

Carrier Frequency The frequency of the constant, periodic, switching waveform that the inverter modulates to generate the AC output to the motor. See also *PWM*.

CE A regulatory agency for governing the performance of electronic products in Europe. Drive installations designed to have CE approval must have particular filter(s) installed in the application.

Choke An inductor which is tuned to react at radio frequencies is called a "choke," since it attenuates (chokes) frequencies above a particular threshold. Tuning is often accomplished by using a movable magnetic core. In variable-frequency drive systems, a choke positioned around high-current wiring can help attenuate harmful harmonics and protect equipment. See also *harmonics*.

DC Braking The inverter DC braking feature stops the AC commutation to the motor, and sends a DC current through the motor windings in order to stop the motor. Also called "DC injection braking," it has little effect at high speed, and is used as the motor is nearing a stop.

Dead Band In a control system, the range of input change for which there is no perceptible change in the output. In PID loops, the error term may have a dead band associated with it. Dead band may or may not be desirable; it depends on the needs of the application.

Digital Operator Panel For Hitachi inverters, "digital operator panel" (DOP) refers first to the operator keypad on the front panel of the inverter. It also includes hand-held remote keypads, which connect to the inverter via a cable. Finally, the DOP Plus is a PC-based software simulation of the keypad devices.

Diode A semiconductor device which has a voltage-current characteristic that allows current to flow only in one direction, with negligible leakage current in the reverse direction. See also *rectifier.*

Duty Cycle 1. The percent of time a square wave of fixed frequency is on (high) versus off (low). 2. The ratio of operating time of a motor, braking resistor, etc. to its resting time. This parameter usually is specified in association with the allowable thermal rise for the device.

Dynamic Braking The optional dynamic braking unit shunts the motor-generated EMF energy into a special braking resistor. The added dissipation (braking torque) is effective at higher speeds, having almost no effect as the motor nears a stop.

Error In process control, the error is the difference between the desired value or setpoint (SP) and the actual value of a the process variable (PV). See also *process variable* and *PID Loop.*

EMI Electromagnetic Interference - In motor/drive systems, the switching of high currents and voltages creates the possibility of generating radiated electrical noise that may interfere with the operation of nearby sensitive electrical instruments or devices. Certain aspects of an installation, such as long motor lead wire lengths, tend to increase the chance of EMI. Hitachi provides accessory filter components you can install to decrease the level of EMI.

Four-quadrant operation Referring to a graph of torque versus direction, a four-quadrant drive can turn the motor either forward or reverse, as well as decelerate in either direction (see also *reverse torque*). A load that has a relatively high inertia and must move in both directions and change directions rapidly requires four-quadrant capability from its drive.

Free-run Stop A method of stopping a motor, caused when the inverter simply turns off its motor output connections. This may allow the motor and load to coast to a stop, or a mechanical brake may intervene and shorten the deceleration time.

Frequency Setting While frequency has a broad meaning in electronics, it typically refers to motor speed for variable-frequency drives (inverters). This is because the output frequency of the inverter is variable, and is proportional to the attained motor speed. For example, a motor with a base frequency of 60 Hz can be speed controlled with an inverter output varying form 0 to 60 Hz. See also *base frequency, carrier frequency,* and *slip*.

Harmonics According to Fourier Series mathematics, a periodic (repeating) function (waveform) can be expressed as a the summation of a series of pure sine waves of related frequencies. The lowest frequency is the fundamental, while all the other wave components are called *harmonics*. The square waves used in inverters produce high-frequency harmonics, even though the main goal is to produce lower-frequency sine waves. These harmonics can be harmful to electronics (including motor windings) and cause radiated energy that interferes with nearby electronic devices. A choke is sometimes used to suppress the transmission of harmonics in an electrical system. See also c*hoke*.

Horsepower A unit of physical measure to quantify the amount of work done per unit of time. You can directly convert between horsepower and Watts as measurements of power.

IGBT **Insulated Gate Bipolar Transistor** (IGBT) - a semiconductor transistor capable of conducting very large currents when in saturation and capable of withstanding very high voltages when it is off. This high-power bipolar transistor is the type used in Hitachi inverters.

Inertia The natural resistance a stationary object to being moved by an external force. See also *momentum*.

Intelligent Terminal A configurable input or output logic function on the Hitachi inverters. Each terminal may be assigned one of several functions.

Inverter A device that electronically changes DC to AC current through a alternating process of switching the input to the output, inverted and non-inverted. A variable speed drive such as the Hitachi L100 is also called an inverter, since it contains three inverter circuits to generate 3-phase output to the motor.

Isolation Transformer A transformer with 1:1 voltage ratio that provides electrical isolation between its primary and secondary windings. These are typically used on the power input side of the device to be protected. An isolation transformer can protect equipment from a ground fault or other malfunction of nearby equipment, as well as attenuate harmful harmonics and transients on the input power.

Jogging Operation Usually done manually, a jog command from an operator's panel requests the motor/drive system to run indefinitely in a particular direction, until the machine operator ends the jog operation.

Momentum The physical property of a body in motion that causes it to continue to move in a straight line. In the case of motors, the armature and shaft are rotating and possesses angular momentum.

Multi-speed Operation The ability of a motor drive to store preset discrete speed levels for the motor, and control motor speed according to the currently selected speed preset. The Hitachi inverters have 16 preset speeds.

Motor Load In motor terminology, motor load consists of the inertia of the physical mass that is moved by the motor and the related friction from guiding mechanisms. See also *inertia*.

NEC The National Electric Code is a regulatory document that governs electrical power and device wiring and installation in the United States.

NEMA The National Electric Manufacturer's Association. NEMA Codes are a published series of device ratings standards. Industry uses these to evaluate or compare the performance of devices made by various manufacturers to a known standard.

Power Factor A ratio that expresses a phase difference (timing offset) between current and voltage supplied by a power source to a load. A perfect power factor = 1.0 (no phase offset). Power factors less than one cause some energy loss in power transmission wiring (source to load).

PID Loop Proportional - Integral-Derivative - a mathematical model used for process control. A process controller maintains a process variable (PV) at a setpoint (SP) by using its PID algorithm to compensate for dynamic conditions and vary its output to drive the PV toward the desired value. For variable-frequency drives, the process variable is the motor speed. See also *error.*

Process Variable A physical property of a process which is of interest because it affects the quality of the primary task accomplished by the process. For an industrial oven, temperature is the process variable. See also *PID Loop* and *error.*

PWM Pulse-width modulation: A type of AC adjustable frequency drive that accomplishes frequency and voltage control at the output section(inverter) of the drive. The drive output voltage waveform is at a constant amplitude, and by "chopping" the waveform (pulse-width-modulating), the average voltage is controlled. The chopping frequency is sometimes called the *carrier frequency.*

Reactance The impedance of inductors and capacitors has two components. The resistive part is constant, while the reactive part changes with applied frequency. These devices have a complex impedance (complex number), where the resistance is the real part and the reactance is the imaginary part.

Rectifier An electronic device made of one or more diodes which converts AC power into DC power. Rectifiers are usually used in combination with capacitors to filter (smooth) the rectified waveform to closely approximate a pure DC voltage source.

Regenerative Braking A particular method of generating reverse torque to a motor, an inverter will switch internally to allow the motor to become a generator and will store the energy internally and/or deliver the braking energy back to the power input mains.

Regulation The quality of control applied to maintain a parameter of interest at a desired value. Usually expressed as a percent (+/-) from the nominal, motor regulation usually refers to its shaft speed.

Reverse Torque The force of available from some types of inverters to change the direction of rotation of a motor shaft. As such, reverse torque is a decelerating force on the motor and its external load.

Rotor The windings of a motor that rotate, being physically coupled to the motor shaft. See also *stator.*

Saturation Voltage For a transistor semiconductor device, it is in saturation when an increase in input (gate) current no longer results in an increase in the output (source/drain) current. The saturation voltage is the voltage from the power source to the transistor output (Vsource to Vdrain). The ideal saturation voltage is zero.

Sensorless Vector Control A technique used in variable-frequency drives (such as SJ100 series) to rotate the force vector in the motor without the use of a shaft position sensor (angular). Benefits include an increase in torque at the lowest speed and the cost savings from the lack of a shaft position sensor.

Setpoint (SP) The setpoint is the desired value of a process variable of interest. See also *Process Variable (PV)* and *PID Loop.*

Single-phase An AC power source consisting of Hot and Neutral wires. An Earth Ground connection usually accompanies them. In theory, the voltage potential on Neutral stays at or near Earth Ground, while Hot varies sinusoidally above and below Neutral. This power source is named Single Phase to differentiate it from three-phase power sources. Some Hitachi inverters can accept single phase input power, but they all output three-phase power to the motor. See also *three-phase*.

Slip The difference between the theoretical speed of a motor at no load (determined by its inverter output waveforms) and the actual speed. Some slip is essential in order to develop torque to the load, but too much will cause excessive heat in the motor windings and/or cause the motor to stall.

Squirrel Cage A “nick-name” for the appearance of the rotor frame assembly for an AC induction motor.

Stator The windings in a motor that are stationary and coupled to the power input of the motor. See also *rotor*.

Tachometer 1. A signal generator usually attached to the motor shaft for the purpose of providing feedback to the speed controlling device of the motor. 2. A speed-monitoring test meter which may optically sense shaft rotation speed and display it on a readout.

Thermal Switch An electromechanical safety device that opens to stop current flow when the temperature at the device reaches a specific temperature threshold. In variable-speed drive systems, thermal switches are typically installed at or near the motor, in order to protect the windings from heat damage.

Three-phase An AC power source with three Hot connections that have phase offsets of 120 degrees is a 3-phase power source. Usually, Neutral and Earth Ground wires accompany the three Hot connections. Loads may be configured in a delta or Y configuration. A Y-connected load such as an AC induction motor will be a balanced load; the currents in all the Hot connections are the same. Therefore, the Neutral connection is theoretically zero. This is why inverters, which generate 3-phase power for motors, do not generally have a Neutral connection to the motor. However, the Earth Ground connection is important for safety reasons, and is provided.

Torque The rotational force exerted by a motor shaft. The units of measurement consist of the distance (radius from shaft center axis) and force (weight) applied at that distance. Units are usually given as pound-feet, ounce-inches, or Newton-meters.

Transistor A solid state, three-terminal device that provides amplification of signals and can be used for switching and control. While transistors have a linear operating range, inverters use them as high-powered switches. Recent developments in power semiconductors has produced transistors capable of handling hundreds of volts and tens of Amperes or more, all with high reliability. The saturation voltage has been decreasing, resulting in less heat dissipation. Hitachi inverters use state-of-the-art semiconductors to provide high performance and reliability, all in a compact package. See also *IGBT* and *saturation voltage*.

Trip An event which causes the inverter to stop operation is called a "trip" event (as in *tripping* a circuit breaker). The inverter keeps a history log of trip events. They also require an action to clear.

Appendix A

Bibliography

Title	Author and Publisher
Variable Speed Drive Fundamentals, 2nd Ed.	Phipps, Clarence A. The Fairmont Press, Inc. / Prentice-Hall, Inc. 1997 ISBN 0-13-636390-3
Electronic Variable Speed Drives	Brumbach, Michael E. Delmar Publishers 1997 ISBN 0-8273-6937-9
Hitachi Inverter Technical Guide Book	Published by Hitachi, Ltd. Japan 1995 Publication SIG-E002

Drive Parameter Settings Tables

B

In This Appendix.... page

Introduction

This appendix lists the user-programmable parameters for the L100 series inverters and the default values for European and U.S. product types. The right-most column of the tables is blank, so you can record values you have changed from the default. This involves just a few parameters for most applications. The two sections in this appendix present the parameters in a format oriented toward two different programming devices:

- the keypad on the inverter, and
- the digital operator panel software (DOP Plus) for the PC

Please refer to the section corresponding to your preferred programming tool.

Parameter Settings for Keypad Entry

L100 series inverters provide many functions and parameters which can be configured by the user. We recommend that you record all parameters which have been edited, in order to help in troubleshooting or recovery from a loss of parameter data.

Inverter model L100 _____

MFG. No. _____

} This information is printed on the specification label located on the right side of the inverter.

Main Profile Parameters

"F" Group Parameters		Default Setting		User Setting
Func. Code	**Name**	**-FE (Europe)**	**-FU (USA)**	
F01	Output frequency setting	0.0	0.0	
F02	Acceleration 1	10.0	10.0	
F03	Deceleration 1	10.0	10.0	
F04	Running direction setting	0.0	0.0	

Standard Functions

"A" Group Parameters		Default Setting		User Setting
Func. Code	Name	-FE (Europe)	-FU (USA)	
A01	Frequency source setting	01	01	
A02	Run command source setting	01	01	
A03	Base frequency setting	50.0	60.0	
A04	Maximum frequency setting	50.0	60.0	
A11	External frequency output zero reference	0	0	
A12	External frequency output span reference	0	0	
A13	External frequency input bias start	0	0	
A14	External frequency input bias end	100	100	
A15	External frequency offset enable	01	01	
A16	External frequency filter time const.	8	8	
A20	Multi-speed 0 setting	0	0	
A21	Multi-speed 1 setting	0	0	
A22	Multi-speed 2 setting	0	0	
A23	Multi-speed 3 setting	0	0	
A24	Multi-speed 4 setting	0	0	
A25	Multi-speed 5 setting	0	0	
A26	Multi-speed 6 setting	0	0	
A27	Multi-speed 7 setting	0	0	
A28	Multi-speed 8 setting	0	0	
A29	Multi-speed 9 setting	0	0	
A30	Multi-speed 10 setting	0	0	
A31	Multi-speed 11 setting	0	0	
A32	Multi-speed 12 setting	0	0	
A33	Multi-speed 13 setting	0	0	
A34	Multi-speed 14 setting	0	0	
A35	Multi-speed 15 setting	0	0	
A38	Jog frequency setting	1.0	1.0	
A39	Jog stop mode	00	00	
A41	Torque boost method selection	0	0	
A42	Manual torque boost value	11	11	

"A" Group Parameters		Default Setting		User Setting
Func. Code	**Name**	**-FE (Europe)**	**-FU (USA)**	
A43	Manual torque boost frequency adjustment	10.0	10.0	
A44	V/F characteristic curve selection	00	00	
A45	V/F gain setting	100	100	
A51	DC braking enable	00	00	
A52	DC braking frequency setting	0.5	0.5	
A53	DC braking wait time	0.0	0.0	
A54	DC braking force setting	0	0	
A55	DC braking time setting	0.0	0.0	
A61	Frequency upper limit setting	0.0	0.0	
A62	Frequency lower limit setting	0.0	0.0	
A63, A65, A67	Jump (center) frequency setting	0.0	0.0	
A64, A66, A68	Jump (hysteresis) frequency width setting	0.5	0.5	
A71	PID Function Enable	00	00	
A72	PID proportional gain	1.0	1.0	
A73	PID integral time constant	1.0	1.0	
A74	PID derivative gain	0.0	0.0	
A75	PV scale conversion	1.00	1.00	
A76	PV source setting	00	00	
A81	AVR function select	02	02	
A82	AVR voltage select	230/400	230/460	
A92	Second acceleration time setting	15.0	15.0	
A93	Second deceleration time setting	15.0	15.0	
A94	Select method to use second accel/ decel	00	00	
A95	Acc1 to Acc2 frequency transition point	0.0	0.0	
A96	Dec1 to Dec2 frequency transition point	0.0	0.0	
A97	Acceleration curve selection	00	00	
A98	Deceleration curve setting	00	00	

Fine Tuning Functions

"B" Group Parameters		Default Setting		User Setting
Func. Code	**Name**	**-FE (Europe)**	**-FU (USA)**	
B01	Selection of restart mode	00	00	
B02	Allowable under-voltage power failure time	1.0	1.0	
B03	Delay before motor restart time	1.0	1.0	
B12	Level of electronic thermal setting	Rated current for each inverter	Rated current for each inverter	
B13	Electronic thermal characteristic	01	01	
B21	Overload restriction operation mode	01	01	
B22	Overload restriction setting	Rated current x 1.25	Rated current x 1.25	
B23	Deceleration rate at overload restriction	1.0	1.0	
B31	Software lock mode selection	01	01	
B32	Reactive current setting	Rated current x 0.58	Rated current x 0.58	
B81	Analog frequency meter adjustment	80	80	
B82	Start frequency adjustment	0.5	0.5	
B83	Carrier frequency setting	5.0	5.0	
B84	Initialization mode (parameters or trip history)	00	00	
B85	Country code for initialization	01	02	
B86	Frequency scalar conversion factor	1.0	1.0	
B87	STOP key enable	00	00	
B88	Resume on FRS cancellation mode	00	00	
B89	Data select for digital op. OPE-J	01	01	

Intelligent Terminal Functions

"C" Group Parameters		Default Setting		User Setting
Func. Code	**Name**	**-FE (Europe)**	**-FU (USA)**	
C01	Terminal 1 function	00	00	
C02	Terminal 2 function	01	01	
C03	Terminal 3 function	02	16	
C04	Terminal 4 function	03	13	
C05	Terminal 5 function	18	18	
C11	Terminal 1 active state	00	00	
C12	Terminal 2 active state	00	00	
C13	Terminal 3 active state	00	00	
C14	Terminal 4 active state	00	01	
C15	Terminal 5 active state	00	00	
C21	Terminal 11 function (logical)	01	01	
C22	Terminal 12 function (logical)	00	00	
C23	Terminal FM function (analog)	00	00	
C31	Terminal 11 active state	00	00	
C32	Terminal 12 active state	00	00	
C33	Alarm relay active state	01	01	
C41	Overload level setting	Inverter rated current	Inverter rated current	
C42	Frequency arrival setting for accel.	0.0	0.0	
C43	Arrival frequency setting for decel.	0.0	0.0	
C44	PID deviation level setting	3.0	3.0	
C91	Debug mode selection	00	00	Do not edit

Parameter Settings for DOP/DRW/DOP Plus

L100 series inverters provide many functions and parameters which can be configured by the user. We recommend that you record all parameters which have been edited, in order to help in troubleshooting or recovery from a loss of parameter data.

Inverter model L100 _____

MFG. No. _____

} This information is printed on the specification label located on the right side of the inverter.

Monitor Mode Parameters

Monitor Mode Setup		Displayed Default Setting		User Setting
Func. Code	**Name**	**-FE (Europe)**	**-FU (USA)**	
Mon.	Frequency setting	TM 000.0 0.0Hz	TM 031.6 0.0Hz	
	Acceleration time	ACC1 0010.0s	ACC1 0010.0s	
	Deceleration time	DEC1 0010.0s	DEC1 0010.0s	
	Frequency setting	F-SET-SELECT TRM	F-SET-SELECT TRM	
	Frequency source select	F/R-SELECT TRM	F/R-SELECT TRM	
	Scaled frequency value	/Hz01.0 0.00	/Hz01.0 0.00	
	Output current display	Im 0.0A 0.0%	Im 0.0A 0.0%	
	Reactive current display	IO 0.00A	IO 0.00A	
	Manual torque boost	V-Boost code 11	V-Boost code 11	
	Torque boost frequency setting	V-Boost F 10.0%	V-Boost F 10.0%	
	Torque boost mode	V-Boost Mode 0	V-Boost Mode 0	
	Output voltage gain adj.	V-Gain 100%	V-Gain 100%	
	Jog frequency	Jogging 1.00Hz	Jogging 1.00Hz	
	Jog mode select	Jog Mode 0	Jog Mode 0	
	Analog adjustment	ADJ 080	ADJ 080	
	Panel display selection	PANEL d01	PANEL d01	
	Terminal monitor	TERM LLL LLLLLL	TERM LLL LLLLLL	

Monitor Mode Setup		Displayed Default Setting		User Setting
Func. Code	**Name**	**-FE (Europe)**	**-FU (USA)**	
Mon.	Alarm display	ERR1 Under.V	ERR1 Under.V	
		ERR1 10.0Hz	ERR1 10.0Hz	
		ERR1 0.2A	ERR1 0.2A	
		ERR1 189.8Vdc	ERR1 189.8Vdc	
		ERR1 RUN 000003H	ERR1 RUN 000003H	
	Total alarm count	ERROR COUNT 002	ERROR COUNT 002	
	Trip history, previous alarm (example)	ERR2 Under.V	ERR2 Under.V	
		ERR2 10.0Hz	ERR2 10.0Hz	
		ERR2 0.2A	ERR2 0.2A	
		ERR2 189.8Vdc	ERR2 189.8Vdc	
		ERR2 RUN 000003H	ERR2 RUN 000003H	
	Trip history, 2nd previous alarm	ERR3 #	ERR3 #	

Function Mode Setup

Function Mode Setup		Displayed Default Setting		User Setting
Func. Code	**Name**	**-FE (Europe)**	**-FU (USA)**	
F-00	Base frequency setting	F-BASE 050Hz	F-BASE 060Hz	
F-01	Maximum frequency setting	F-MAX 050Hz	F-MAX 060Hz	
F-02	Start frequency adjustment	Fmin 0.5Hz	Fmin 0.5Hz	
F-03	Motor input voltage	AVR AC 230V	AVR AC 230V	
	AVR function for deceleration	AVR MODE DOFF	AVR MODE DOFF	
F-04	Control method setting	CONTROL VC	CONTROL VC	
F-06	Acceleration time 1	ACC 1 0010.0s	ACC 1 0010.0s	
	2-stage acceleration time	ACC CHG TM	ACC CHG TM	
	Acceleration time 2	ACC 2 0015.0s	ACC 2 0015.0s	
	Acceleration time change frequency	ACC CHFr 000.0Hz	ACC CHFr 000.0Hz	
	Acceleration curve selection	ACC LINE L	ACC LINE L	

Function Mode Setup		Displayed Default Setting		User Setting
Func. Code	Name	-FE (Europe)	-FU (USA)	
F-07	Deceleration time 1	DEC 1 0010.0s	DEC 1 0010.0s	
	Deceleration time 2	DEC 2 0015.0s	DEC 2 0015.0s	
	Deceleration time change frequency setting	DEC CHFr 000.0Hz	DEC CHFr 000.0Hz	
	Deceleration curve setting	DEC LINE L	DEC LINE L	
F-10	Restart after FRS signal selection	RUN FRS ZST	RUN FRS ZST	
F-11	Output frequency setting	SPD FS 000.0Hz	SPD FS 000.0Hz	
	Multi-stage 1 setting	SPD 1 000.0Hz	SPD 1 000.0Hz	
	Multi-speed 2 setting	SPD 2 000.0Hz	SPD 2 000.0Hz	
	Multi-speed 3 setting	SPD 3 000.0Hz	SPD 3 000.0Hz	
	Multi-speed 4 setting	SPD 4 000.0Hz	SPD 4 000.0Hz	
	Multi-speed 5 setting	SPD 5 000.0Hz	SPD 5 000.0Hz	
	Multi-speed 6 setting	SPD 6 000.0Hz	SPD 6 000.0Hz	
	Multi-speed 7 setting	SPD 7 000.0Hz	SPD 7 000.0Hz	
	Multi-speed 8 setting	SPD 8 000.0Hz	SPD 8 000.0Hz	
	Multi-speed 9 setting	SPD 9 000.0Hz	SPD 9 000.0Hz	
	Multi-speed 10 setting	SPD 10 000.0Hz	SPD 10 000.0Hz	
	Multi-speed 11 setting	SPD 11 000.0Hz	SPD 11 000.0Hz	
	Multi-speed 12 setting	SPD 12 000.0Hz	SPD 12 000.0Hz	
	Multi-speed 13 setting	SPD 13 000.0Hz	SPD 13 000.0Hz	
	Multi-speed 14 setting	SPD 14 000.0Hz	SPD 14 000.0Hz	
	Multi-speed 15 setting	SPD 15 000.0Hz	SPD 15 000.0Hz	
F-20	DC braking enable	DCB SW OFF	DCB SW OFF	
	DC braking frequency	DCB F 00.5Hz	DCB F 00.5Hz	
	DC braking time delay	DCB WAIT 0.0s	DCB WAIT 0.0s	
	DC braking force	DCB V 000	DCB V 000	
	DC braking time	DCB T 00.0s	DCB T 00.0s	
F-22	Allowable instantaneous power failure	IPS UVTIME 01.0s	IPS UVTIME 01.0s	
	Standby time after power failure recovery	IPS WAIT 001.0s	IPS WAIT 001.0s	
	Instantaneous power failure restart selection	IPS POWR ALM	IPS POWR ALM	

Function Mode Setup		Displayed Default Setting		User Setting
Func. Code	Name	-FE (Europe)	-FU (USA)	
F-23	Electronic thermal cut-off characteristic	E-THM CHAR CRT	E-THM CHAR CRT	
	Electronic thermal level	E-THM LVL 01.40A (rated output current)	E-THM LVL 01.40A (rated output current)	
F-24	Overload limit setting	OLOAD LVL 01.75A (rated current * 1.25A)	OLOAD LVL 01.75A (rated current * 1.25A)	
	Overload limit constant	OLOAD CONST 01.0	OLOAD CONST 01.0	
	Overload limit load	OLOAD MODE ON	OLOAD MODE ON	
F-25	Software lock selection	S-LOCK MD1	S-LOCK MD1	
F-26	Frequency lower limit	LIMIT L 000.0Hz	LIMIT L 000.0Hz	
	Frequency upper limit	LIMIT H 000.0Hz	LIMIT H 000.0Hz	
F-27	Jump frequency 1	JUMP F1 000.0Hz	JUMP F1 000.0Hz	
	Jump frequency 2	JUMP F2 000.0Hz	JUMP F2 000.0Hz	
	Jump frequency 3	JUMP F3 000.0Hz	JUMP F3 000.0Hz	
	Jump frequency width (hysteresis) 1	JUMP W1 00.5Hz	JUMP W1 00.5Hz	
	Jump frequency width (hysteresis) 3	JUMP W2 00.5Hz	JUMP W2 00.5Hz	
	Jump frequency width (hysteresis) 3	JUMP W3 00.5Hz	JUMP W3 00.5Hz	
F-28	Stop key enable during terminal mode	STOP-SW ON	STOP-SW ON	
F-31	External frequency start (output bias setting)	IN EXS 000.0Hz	IN EXS 000.0Hz	
	External frequency end (output span setting)	IN EXE 000.0Hz	IN EXE 000.0Hz	
	External frequency start (input bias	IN EX%S 000%	IN EX%S 000%	
	External frequency start (input span)	IN EX%E 100%	IN EX%E 100%	
	External frequency start point (input offset)	IN LEVEL 0Hz	IN LEVEL 0Hz	
	External input filter time constant	IN F-SAMP 8	IN F-SAMP 8	

Function Mode Setup		Displayed Default Setting		User Setting
Func. Code	Name	-FE (Europe)	-FU (USA)	
F-32	Frequency arrival threshold during acceleration	ARV ACC 000.0Hz	ARV ACC 000.0Hz	
	Frequency arrival threshold during deceleration	ARV DEC 000.0Hz	ARV DEC 000.0Hz	
F-33	Overload previous level	OV Load 01.40A (rated current)	OV Load 01.40A (rated current)	
	Error overload (thresh-old) for PID loop	OV PID 003.0%	OV PID 003.0%	
F-34	Intelligent input 1 function code	IN-TM 1 FW	IN-TM 1 FW	
	Intelligent input 2 function code	IN-TM 2 RV	IN-TM 2 RV	
	Intelligent input 3 function code	IN-TM 3 CF1	IN-TM 3 AT	
	Intelligent input 4 function code	IN-TM 4 CF2	IN-TM 4 USP	
	Intelligent input 5 function code	IN-TM 5 RS	IN-TM 5 RS	
	Intelligent input 1 NO/NC (active state)	IN-TM O/C-1 NO	IN-TM O/C-1 NO	
	Intelligent input 2 NO/NC (active state)	IN-TM O/C-2 NO	IN-TM O/C-2 NO	
	Intelligent input 3 NO/NC (active state)	IN-TM O/C-3 NO	IN-TM O/C-3 NO	
	Intelligent input 14 NO/NC (active state)	IN-TM O/C-4 NO	IN-TM O/C-4 NC	
	Intelligent input 5 NO/NC (active state)	IN-TM O/C-5 NO	IN-TM O/C-5 NO	
F-35	Intelligent output 11 function code	OUT-TM 1 FA1	OUT-TM 1 FA1	
	Intelligent output 12 function code	OUT-TM 2 RUN	OUT-TM 2 RUN	
	Relay output NO/NC (active state)	OUT-TM O/C-A NC	OUT-TM O/C-A NC	
	Intelligent output 11 NO/NC (active state)	OUT-TM O/C-1 NO	OUT-TM O/C-1 NO	
	Intelligent output 12 NO/NC (active state)	OUT-TM O/C-2 NO	OUT-TM O/C-2 NO	
F-36	Carrier frequency setting	CARRIER 05.0kHz	CARRIER 05.0kHz	

Function Mode Setup		Displayed Default Setting		User Setting
Func. Code	**Name**	**-FE (Europe)**	**-FU (USA)**	
F-37	Monitor signal selection	MONITOR A-F	MONITOR A-F	
F-38	Initialization country code for default settings	INIT SEL EUR	INIT SEL USA	
	Debug mode display selection	INIT DEBG OFF	INIT DEBG OFF	
	Motor rotation direction	INIT DOPE FWD	INIT DOPE FWD	
	Initial mode selection	INIT MODE TRP	INIT MODE TRP	
F-43	PID loop enable	PID SW OFF	PID SW OFF	
	PID proportional gain	PID P 1.0	PID P 1.0	
	PID integral gain	PID I 001.0s	PID I 001.0s	
	PID derivative gain	PID D 000.0	PID D 000.0	
	PID scale factor setting	PID CONV 01.00	PID CONV 01.00	
	PID input (PV) selection	PID INPT CUR	PID INPT CUR	

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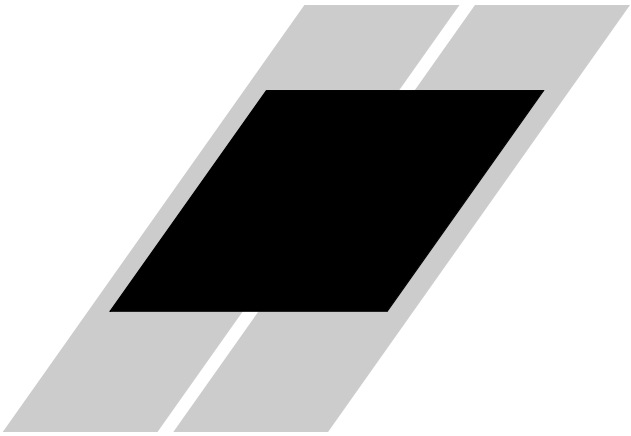

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